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THE CLAY PRODUCTS INDUSTRY OF ONTARIO

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DEPARTMENT OF MINES

Hon. G. C. Wardrope, *Minister*
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J. E. Thomson, *Director, Geological Branch*

The Clay Products Industry of Ontario

By

G. R. GUILLET

Industrial Mineral Report 22

TORONTO
1967

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COVER PHOTO

Durable products from a long-established industry. (Photo courtesy of Canadian Structural Clay Association, Willowdale.)

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Geological Maps
(back pocket)

Map 2130 (coloured)—Principal clay areas of southern Ontario and the clay products industry dependent on clay. Scale, 1 inch to 16 miles.

Map 2131 (coloured)—Principal shale areas of southern Ontario and the clay products industry dependent on shale. Scale, 1 inch to 16 miles.

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Photo 2—A typical Ontario scene in the clay industry; loading brick "cubes" for shipment. (Photo by Panda, Toronto; courtesy Canadian Structural Clay Association, Willowdale.)

FOREWORD

A survey of brick, tile, and sewer-pipe plants, and a study of their clay and shale raw materials, was made in 1961. Most of the plants were revisited in 1965, so that significant developments since the first survey are incorporated in this report. A total of 194 samples of clay and shale were examined by chemical, mineralogical, and ceramic testing methods.

The author wishes to thank the plant operators for their co-operation in this survey. Much assistance was also received from J. G. Brady, Chief of the Ceramic Section of the Mines Branch, Ottawa, and L. J. Chapman of the Ontario Research Foundation. The author is particularly indebted to the Laboratory Branch, Ontario Department of Mines, for all the testwork.

A later volume, "Clay and Shale Resources of Ontario," will detail the chemical, mineralogical, and ceramic properties of clays and shales not yet developed by industry. A third volume, "The Ceramic Industry of Ontario," will describe plants manufacturing glass, porcelain, pottery, porcelain enamel, and refractory products.

GLOSSARY

Geologic Terms

Stratification or bedding: General terms for layering in rocks. Stratification or bedding is the characteristic structural feature of sedimentary rocks produced by the deposition of sediments in beds, layers, strata, laminae, lenses, wedges, and other essentially tabular units. It is due to many different causes: differences of texture, hardness, cohesion or cementation, colour, mineralogical or lithological composition, and internal structure.

Varves: A specific type of stratification characterized by a regular alternation of material due to annual seasonal influences. Each varve represents the deposition during one year and consists ordinarily of a lower silty part deposited in summer and an upper clayey part deposited in winter.

Bedding parting: The tendency of fine-grained sedimentary rocks to split into thin layers parallel to the bedding.

Joints: Fractures or parting planes not parallel to the bedding, and often nearly at right angles to it. In clays and shales they may be caused by shrinkage through dehydration, or by structural disturbances.

Concretion: A well-defined concentration of mineral matter originating later than, and differing notably in composition from, the sediment in which it occurs. Concretions are often round, ellipsoidal, or cylindrical in shape, but they may also have odd irregular shapes; they vary in in size up to many feet. In clays and shales they commonly consist of calcium sulphate, calcium carbonate, or iron oxide. They appear to have formed by the concentric deposition of soluble material, in many cases around an organic or fossil nucleus.

Geode: A hollow concretion, consisting of a thin spherical outer shell lined with inwardly pointing crystals.

Bedding Classification

Massive-bedded: beds more than 36 inches thick
Thick-bedded: 12–36 inches
Medium-bedded: 4–12 inches
Thin-bedded: 2–4 inches
Very thin-bedded: ½–2 inches
Laminated: ⅛–½ inch
Finely laminated: less than ⅛ inch

Parting Classification

Platy parting: more than 1/16 inch thick
Fissile parting: less than 1/16 inch thick

Grain-Size Classification

(Wentworth classification for clastic fragments)

Boulder: more than 256 millimetres
Cobble: 64–256 millimetres
Pebble: 4–64 millimetres
Granule: 2–4 millimetres
Very coarse sand: 1–2 millimetres
Coarse sand: ½–1 millimetres
Medium sand: ¼–½ millimetres
Fine sand: ⅛–¼ millimetres
Very fine sand: 1/16–⅛ millimetres
Silt: 1/256–1/16 millimetres
Clay: less than 1/256 millimetre

Part I Introduction

Although the heavy clay products industry in Ontario had its beginning long before the keeping of statistical records, the major growth of the industry has been in the years following World War II. In the fifteen-year period 1943–1958 the value of heavy clay products increased ten-fold. A peak year in the industry was 1958, when the total value of production was $22,786,291. A slight decline followed, but since 1961, the value of production has again been rising, and in 1964 it was a record $23,723,602.

Heavy clay products include brick, tile, and sewer pipe. The production of brick in large, modern plants accounts for two-thirds of the total value of the heavy clay industry. The production of field drain tile in small scattered plants is an important rural segment of the industry. Structural tile, floor tile, flue linings, sewer pipe, and expanded shale aggregate are also included in heavy clay statistics. Pottery products made from local clay are not covered in this report.

Shales of the Queenston and Dundas formations of Ordovician age are the most important raw materials for brick. It is a fortunate coincidence that these formations are best exposed near Toronto and Hamilton, the major market area for construction materials. Shale of the Hamilton Formation of Devonian age is used for brick and tile at Parkhill and Thedford in southwestern Ontario. In general, the shales of the Queenston, Dundas, and Hamilton formations are red-burning.

Clays of Ontario are practically all Pleistocene or Recent in age, and are closely related to glacial events. Their compositions reflect their bedrock source, and because of the prevalence of limestones in the Paleozoic rocks of southern Ontario, most of the clays are calcareous, have short firing ranges, and burn to buff, porous bodies. Removal of lime by leaching at the surface, or by secondary transport and deposition in most cases results in a red-fired colour and a denser, harder body. Clays derived from Precambrian rocks are commonly red-burning. The clays of Ontario are not widely used for brick, but they are generally well suited for the production of field drain tile. A deposit of clay derived from the Queenston shale near Hamilton is mixed with imported fireclay for the manufacture of sewer pipe, but reserves of this clay are now all but depleted or are unavailable to industry through urban development.

The conservation of raw materials for the heavy clay industry is becoming increasingly important in the urban area of southern Ontario. Shales of the Dundas and Queenston formations outcrop mainly in the heavily populated Toronto-Hamilton area where competition for land use is high. The shales of this region are the principal raw material for 92 percent of Ontario's brick industry—an industry with an annual value of 16 million dollars. Alternative sources of these raw materials are scarce; in the case of Dundas shale, exposures are not found beyond a point 16 miles north of Lake Ontario, until the vicinity of Meaford, 100 miles north of Toronto. Deposits of these shales are restricted by nature and must be utilized where found.

With the advent of modern production facilities, employing smokeless gas-fired kilns and controlled blasting techniques, brick plants are no longer a nuisance or a hazard to the urban scene. Municipal planning boards, concerned with optimum land use, should insure that zoning regulations do not prevent utilization of our mineral resources.

THE HEAVY CLAY PRODUCTS INDUSTRY

The heavy clay products industry is that part of the ceramic industry that deals mainly with large-volume, relatively low-value, products made from local clay or shale. Heavy clay products include brick, drain tile, structural tile, floor tile, flue linings, sewer pipe, and related materials, and are used mainly by the construction industry.

Ontario's heavy clay products industry is the subject of two previous surveys, one by M. B. Baker (1906) and one by R. J. Montgomery (1930). Statistical data concerning the production and marketing of clay products are kept by the Statistician, Ontario Department of Mines, to whom returns are made annually by each producer. Fifty-four plants were operating during 1964; 22 were primarily producers of brick, 29 of drain tile, 2 of sewer pipe, and one of structural tile. The industry is therefore essentially divided betwen producers of brick and producers of drain tile, although some plants produce more than one product (see below). Montgomery (1930, p. 9) shows the number of plants producing brick, drain tile, and structural tile (hollow building-block) in 1906 and 1929; his figures are shown as follows, compared with those for 1964.

Product	No. of Plants 1906	1929	1964
Brick	186	97	25
Drain Tile	51	84	31
Structural Tile	19	23	4

The decline in the number of plants producing heavy clay products is striking; 192 in 1906, 145 in 1929 (Montgomery 1930, p. 9), and 54 in 1964. The change is witness to the continuing trend towards large modern industrial plants with wide marketing ranges, in place of seasonal family enterprises supplying only local needs.

Brick plants are concentrated in the area between Toronto and Hamilton; tile plants are scattered throughout southwestern Ontario. Maps 2130, 2131 (see back pocket) show the location of brick, tile, and sewer-pipe plants using local raw materials in southern Ontario. Statistics for the year 1964 indicate that 10 plants each marketed clay products valued in excess of $500,000; 21 plants had sales between $100,000 and $500,000; 23 plants had sales less than $100,000. Below is a listing of heavy clay products plants, excluding pottery and artware, in these three categories.

Group I: Sales in excess of $500,000 annually

Booth Brick Ltd., Toronto (North York)
Brampton Brick Ltd., Brampton
Canada Brick Ltd., Streetsville
Diamond Clay Products Ltd., Tansley
Domtar Construction Materials Ltd., Cooksville
Domtar Construction Materials Ltd., Ottawa
Milton Brick Co. Ltd., Milton
National Sewer Pipe Ltd., Clarkson
St. Catharines Brick and Tile Co. Ltd., St. Catharines
Toronto Brick Ltd., Toronto

Group II: Sales of $100,000–$500,000 annually

N.S. Bauman Ltd., Wallenstein
Booth Brick Ltd., Toronto (Etobicoke)
Canada Vitrified Products Ltd., St. Thomas
Canadian Pressed Brick Co. Ltd., Hamilton
Deller's Tile Ltd., Brownsville
Dochart Brick and Tile Co. Ltd., Arnprior
Domtar Construction Materials Ltd., Cheltenham*
Dresden Tile Yard Ltd., Dresden
Emig Clay Products Ltd., Chatham
Grimsby Tile Ltd., Grimsby
Hamilton Brick Limited, Hamilton
Hill Tile Ltd., Stevenson
Kitchener Brick Co. Ltd., Kitchener
Earl Lindsay and Sons Ltd., Wallaceburg
Amos. C. Martin Ltd., Parkhill
Amos C. Martin Ltd., Wallenstein
F. B. McFarren Ltd., Streetsville
Napanee Brick and Tile Ltd., Napanee
Natco Clay Products Ltd., Burlington
National Sewer Pipe Ltd., Hamilton
Superior Brick and Tile Co. Ltd., Fort William

Group III: Sales less than $100,000 annually

Beaverton Brick and Tile Co. Ltd., Beaverton
Brantford Clay Products Ltd., Brantford
B. Broadwell and Son, Kingsville
Bruce Brick and Tile Ltd., Teeswater
Central Tile Brick Corp. Ltd., Tilbury
Comber Tile Yard Ltd., Comber
Continental Brick and Tile Ltd., Shallow Lake
George Coultis and Son Ltd., Thedford
Elliott's Brickyard, Sault Ste. Marie
Fletcher Tile Ltd., Fletcher
Gomoll Brick and Tile Ltd., Powassan
Gravell Brick Co. Ltd., North Bay*
J. H. Henderson, Listowel
Home Brick Ltd., Bracebridge
F. W. Howlett and Sons Ltd., Petrolia
Huntsville Brick Works Ltd., Huntsville
D. A. Janes and Son Ltd., Delaware
W. J. McFarlane and Sons Ltd., Forest
Norwich Brick and Tile Ltd., Norwich
Ontario Reformatory, Mimico
Paisley Brick and Tile Co. Ltd., Paisley
Parkhill Brick Co. Ltd., Parkhill
Rydall Brick and Tile Ltd., Elginfield

Competition for the brick market, attending the high rate of construction activity after World War II, stimulated the development of large modern brick plants. Advanced brick technology and improved plant design, incorporating much automated equipment, has made it difficult for older plants, still relying heavily on hand labour, to compete. Stiff-mud extrusion equipment, continuous tunnel kilns, and large uniform reserves of shale are common to practically all brick producers today. Plants producing drain tile have undergone relatively little change. Many tile plants are former brick plants, no longer able to compete in brick, but well located to supply local demands for field drainage tile throughout southwestern Ontario. Stiff-mud extrusion equipment, round downdraft kilns, and small clay deposits are common to most tile plants. Baker (1906, pp. 41–56) and Montgomery (1930, pp. 45–107) have dealt at great length with processes and equipment for the manufacture of heavy clay products, but little is applicable to modern brick-making.

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*Closed January 1, 1965

*Closed March 1965

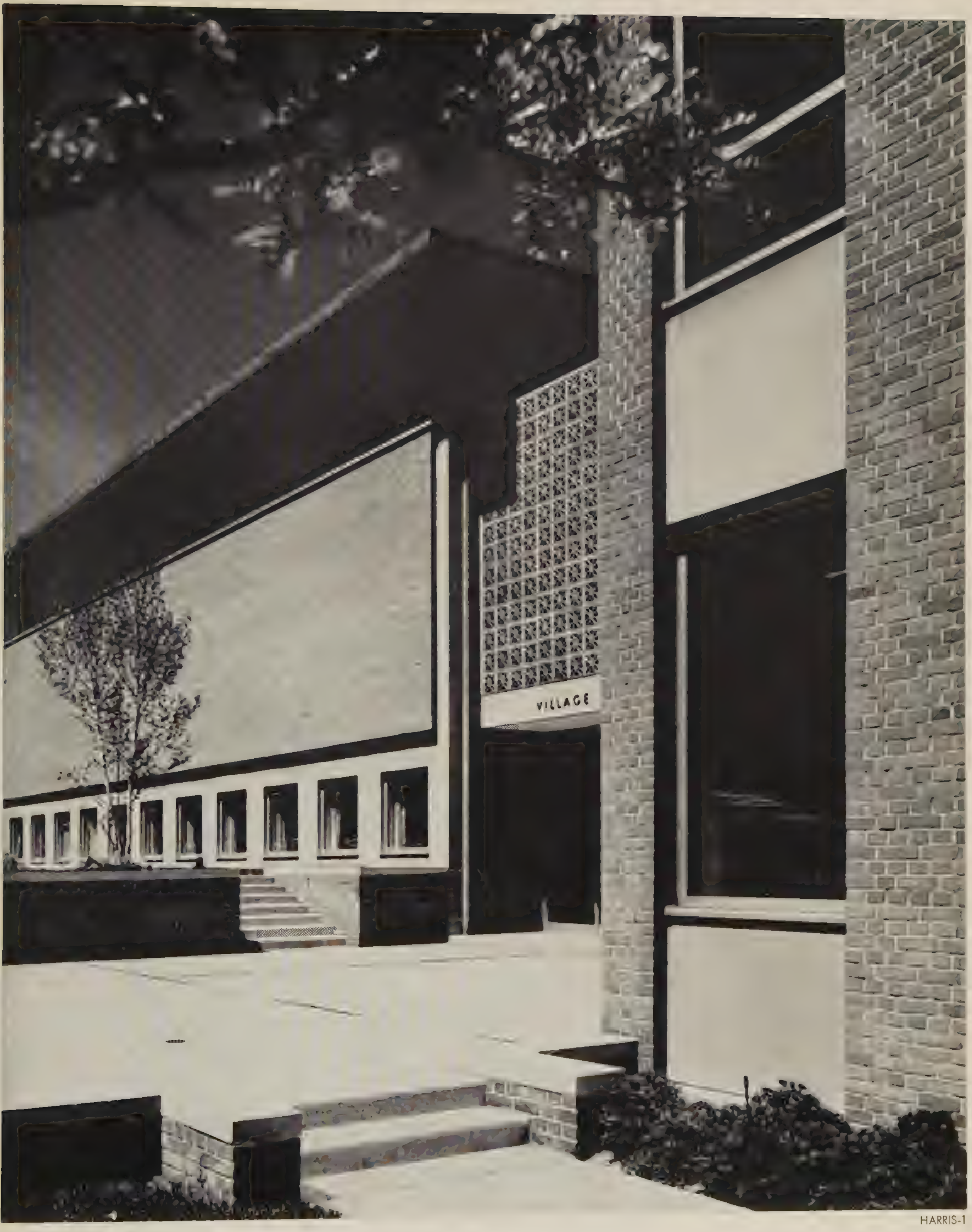

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Photo 3—Municipal building and library; Forest Hill Village, Toronto. (Photo by David G. Harris, Toronto; courtesy Canadian Structural Clay Association, Willowdale.)

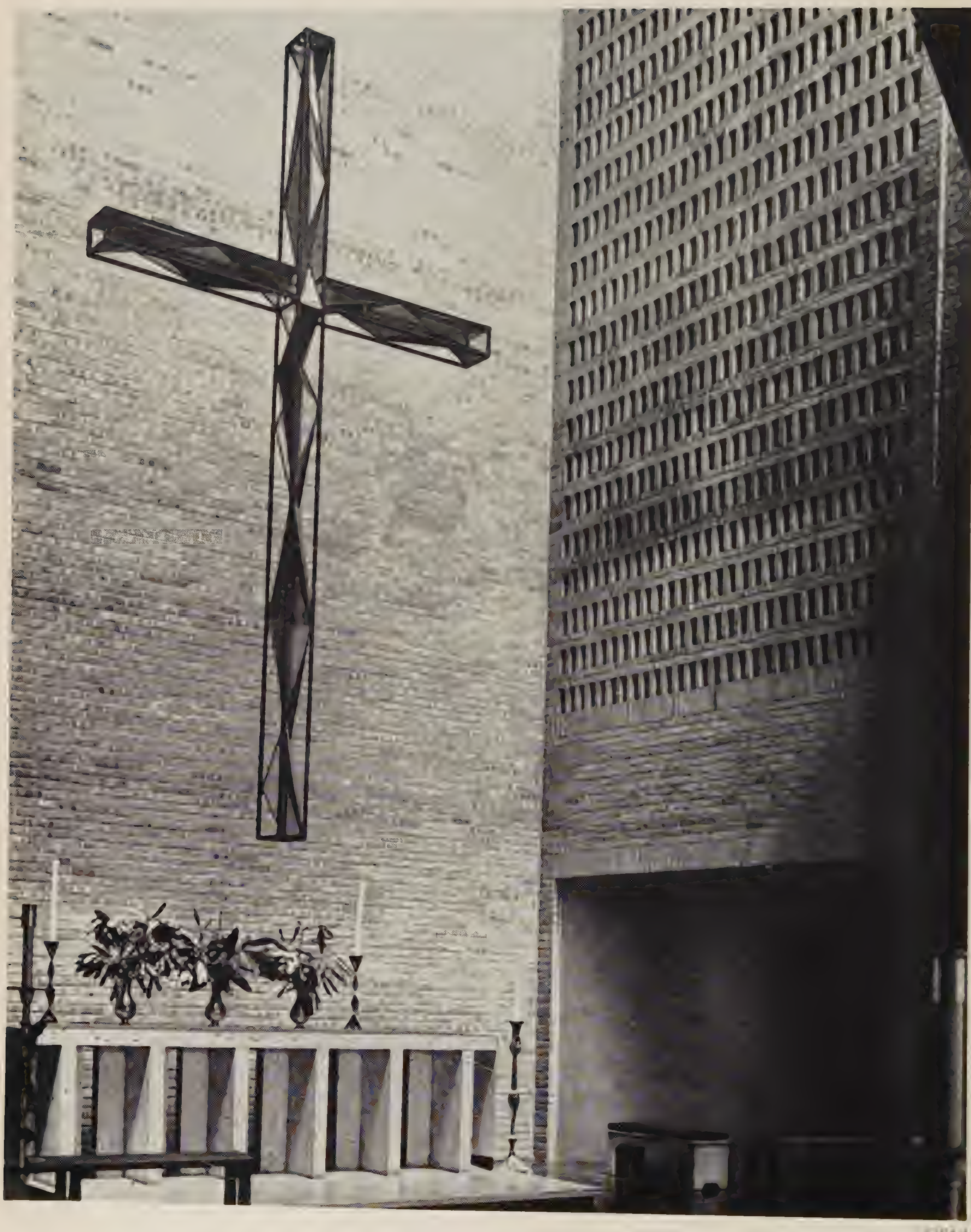

Photo 4—St. Stephens Episcopal Church; Columbus, Ohio, U.S.A.
(Photo courtesy of Canadian Structural Clay Association, Willowdale.)

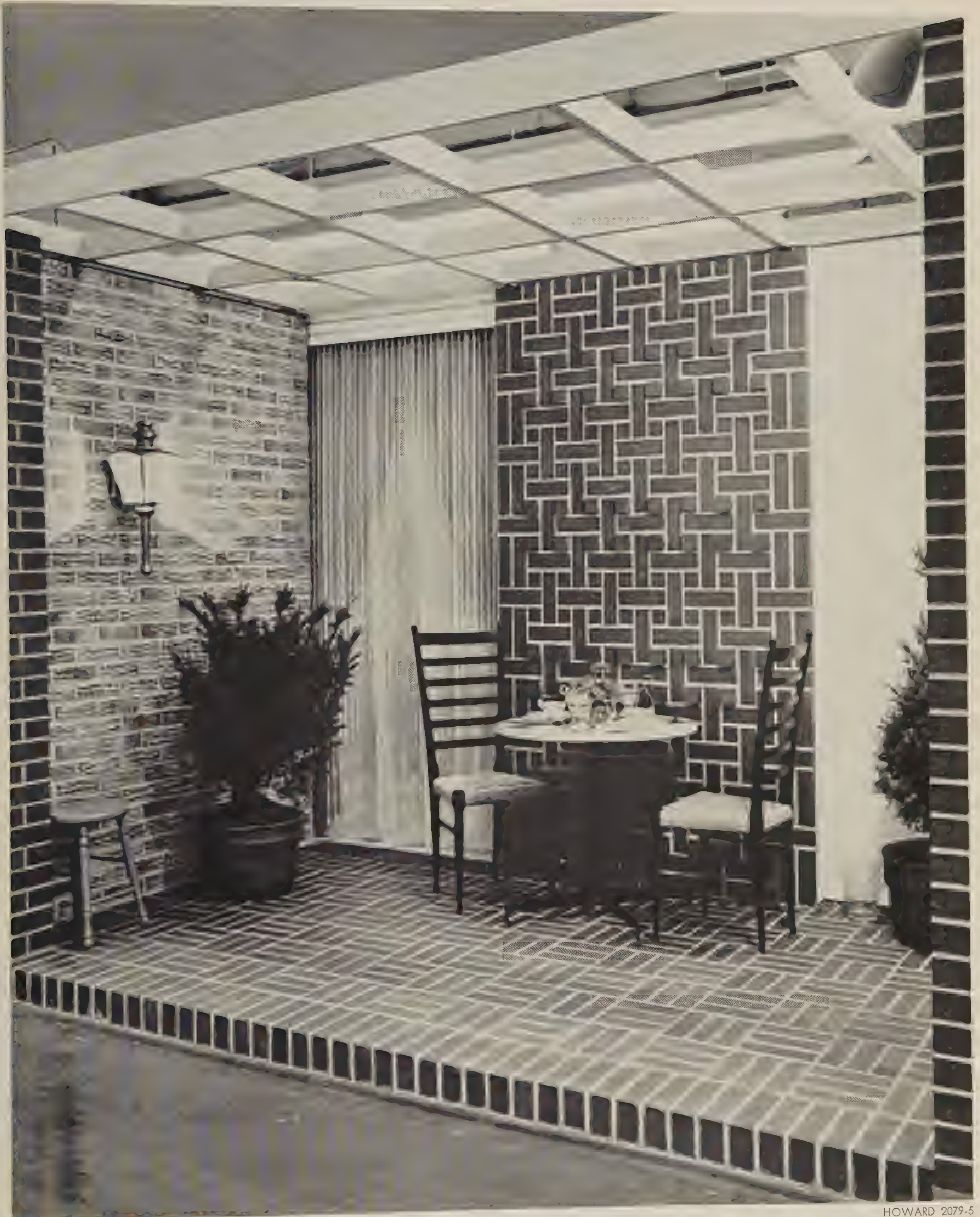

Photo 5—Attractive use of brick; the Home Show, Canadian National Exhibition, Toronto, 1963. (Photo by Howard Photographic Studios, Toronto; courtesy Canadian Structural Clay Association, Willowdale.)

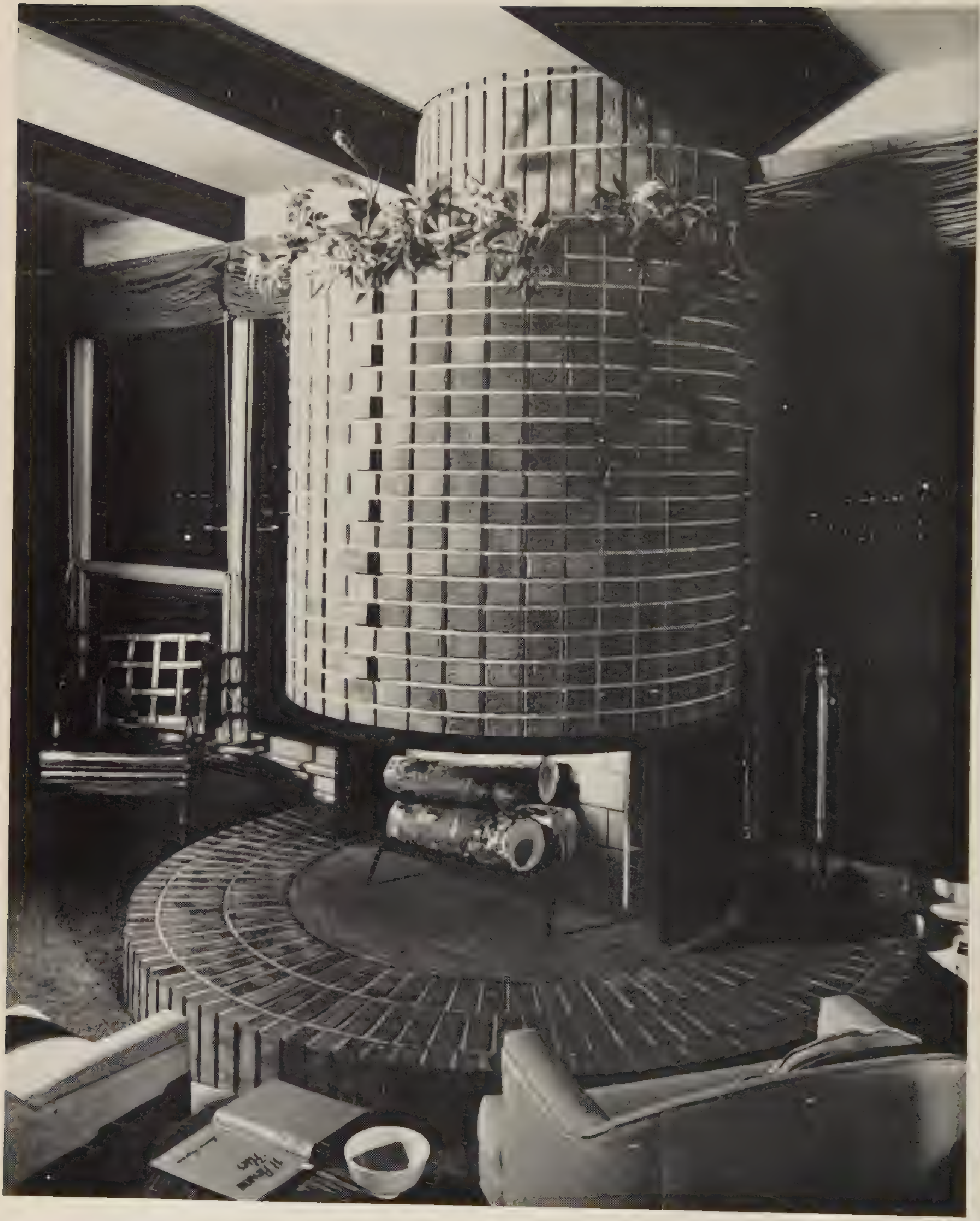

Photo 6--Cantilevered fireplace; Denver, Colorado, U.S.A. (Courtesy Canadian Structural Clay Association, Willowdale.)

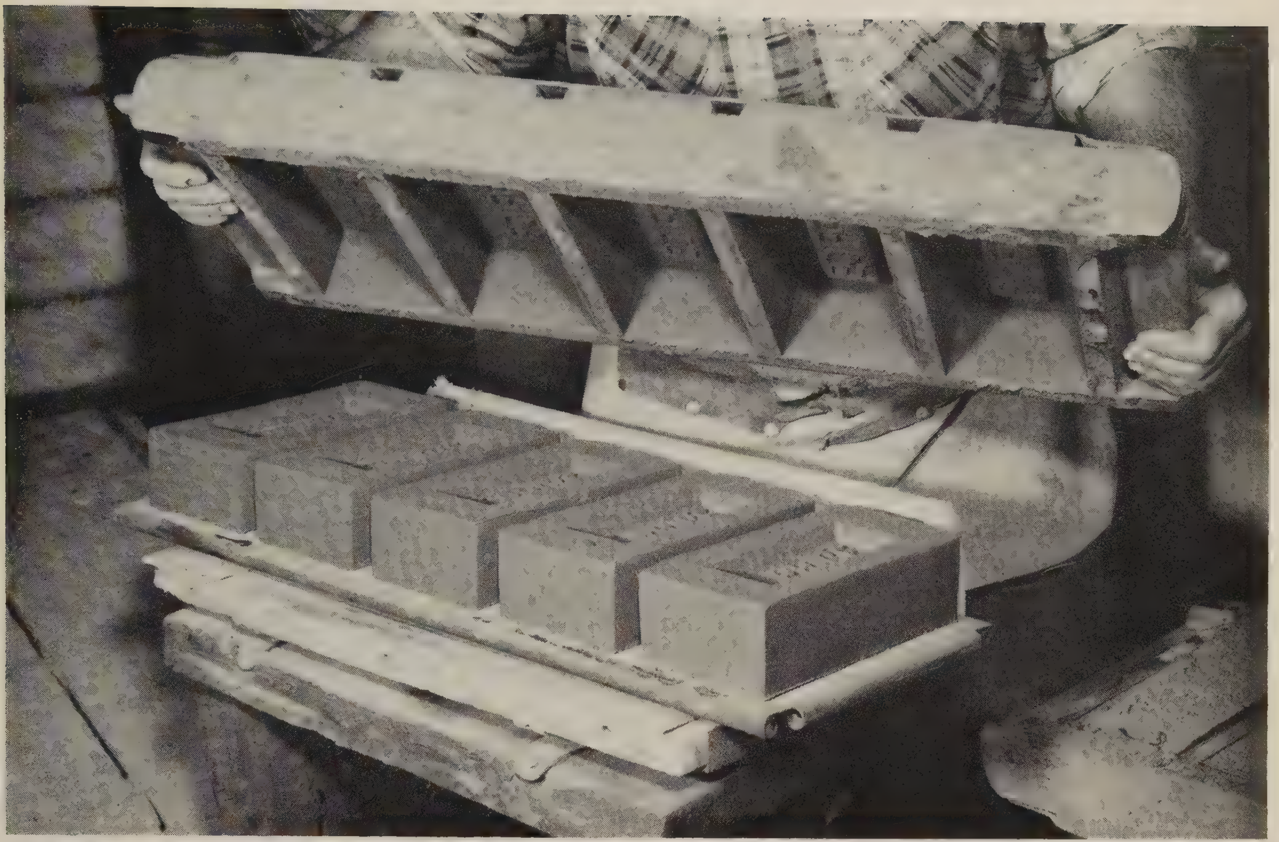

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Photo 7—Removing soft-mud brick from the mould; Toronto Brick Company Limited, Greenwood Avenue plant, 1960. (Photo by Gilbert A. Milne and Co. Ltd., Toronto; courtesy Canadian Structural Clay Association, Willowdale.)

TABLE 1 Production of Heavy Clay Products 1944–1964

Year	Brick		Drain Tile		Total clay products (dollars)
	Volume (1,000's of brick)	Value (dollars)	Volume (1,000's of tile)	Value (dollars)	
1964	313,478	15,574,764	57,597	3,487,602	23,723,602
1963	278,501	13,942,745	53,335	3,094,958	21,819,687
1962	255,527	12,833,593	47,429	2,729,705	20,146,786
1961	235,771	12,557,418	48,479	2,686,550	19,774,288
1960	240,151	12,766,640	51,637	2,954,594	20,191,325
1959	272,469	15,070,844	44,483	2,595,721	22,174,895
1958	273,971	15,300,960	49,163	2,909,168	22,786,291
1957	233,749	12,325,253	41,013	2,407,912	18,353,299
1956	242,000	12,970,884	42,761	2,441,571	19,173,336
1955	232,125	12,378,028	43,398	2,384,413	18,314,320
1954	224,607	11,676,574	37,123	2,056,042	17,230,231
1953	193,393	9,732,373	31,712	1,728,011	14,829,222
1952	218,713	7,610,422	27,409	1,506,992	11,975,200
1951	155,208	6,681,181	23,385	1,243,891	10,484,341
1950	142,667	5,728,115	22,161	1,058,567	9,323,263
1949	123,238	4,660,007	20,592	963,635	7,435,439
1948	120,301	4,089,509	18,811	831,785	6,563,754
1947	112,204	3,199,471	16,255	634,940	5,278,438
1946	104,852	2,815,497	14,709	529,041	4,321,499
1945	76,601	1,956,375	10,233	355,264	3,107,189
1944	56,975	1,342,444	10,785	309,245	2,347,396

Table 1 shows the production record for the period 1944–1964 for brick and drain tile, compared with the total value for heavy clay products. Table 2 is a detailed breakdown for heavy clay products marketed in 1964. The heavy clay products industry employed 355 salaried employees and 2,057 wage-earners in 1963, and paid them $1,682,805 and $6,537,196 respectively (Statistician, Ontario Dept. Mines).

TABLE 2 Heavy Clay Products Marketed in 1964

	Quantity	Value (dollars)
Brick:		
Stiff-mud (wire-cut) process		
face	255,957,000	13,244,585
common	31,145,000	643,843
Dry-press process		
face	5,812,000	243,328
common	793,000	11,585
Soft-mud process		
face	670,000	33,429
common	12,000	648
Fancy or ornamental brick (including special shapes, glazed brick)	17,218,000	1,247,842
Sewer brick	496,000	23,157
Paving brick	1,375,000	126,347
Tile:		
Structural (hollow blocks, including fireproofing and load-bearing tile) (tons)	37,500	743,150
Floor tile (sq. ft.)	1,075,000	120,947
Drain tile	57,597,000	3,487,620
Other:		
Sewer pipe (feet)	2,986,000	1,353,321
Flue linings (feet)	939,000	474,207
Pottery from domestic clay		967,307
Other products (including lightweight shale aggregate)		1,002,304
Total		23,723,602

Brick

HISTORY OF BRICK PRODUCTION IN ONTARIO

The history of brick production in Ontario is marked not only by a decline in the number of producing plants but also by wide fluctuations in the demand for brick. For a few years immediately prior to World War I more than 300 million brick were made annually, a level of production that was not duplicated until 1964. Figure 1 traces the volume and value of brick production from 1900 to 1960, and indicates the number of plants making brick at various times.

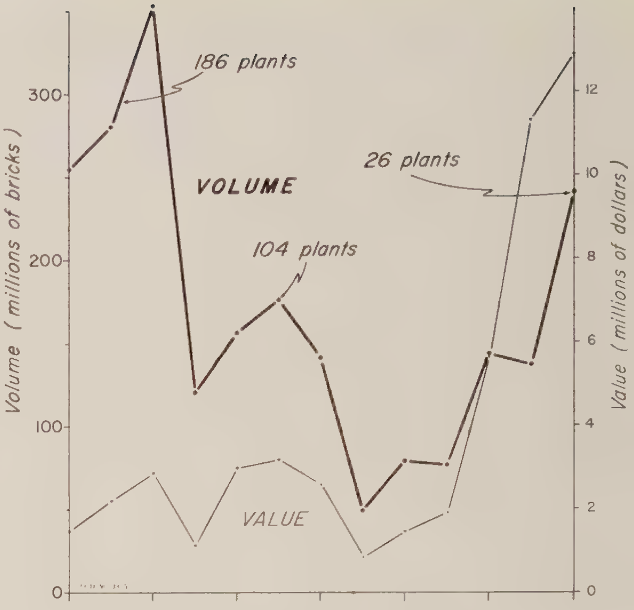
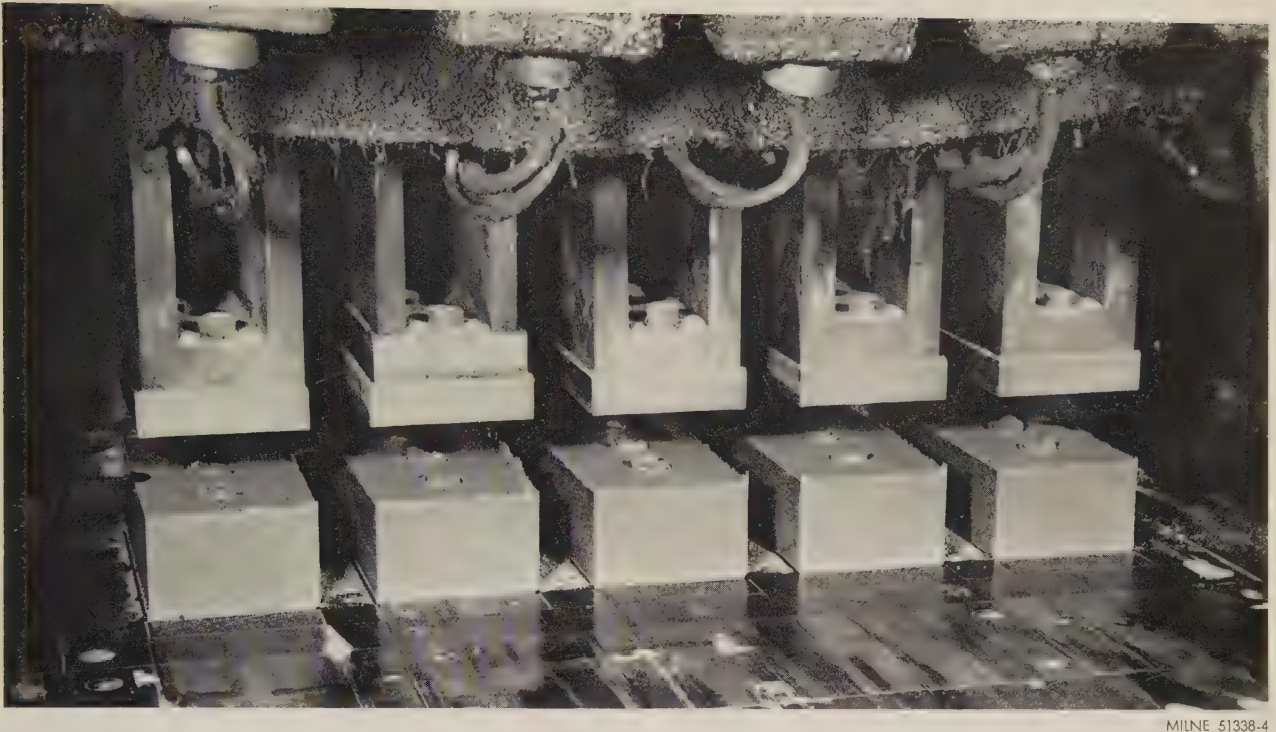


Figure 1—Brick production in Ontario, 1900-1960.

Whereas common, or second quality, brick now comprise less than 10 percent of total brick production, such brick were unavoidably produced in large numbers in the early plants. Unequal burning characteristics inherent in the old kilns resulted in soft, underfired, brick in the lower part of the kiln and overfired, sometimes deformed, brick at the top. Early construction methods made use of these low cost substandard brick for unexposed, back-up, purposes, but improved brick technology and the advent of concrete block coincided to reduce both the supply and demand for cull brick. Today the market is entirely for face brick, and unpredictable consumer demands in colour and texture are a major problem to the industry.

BRICK-FORMING METHODS

There are three methods used in Ontario for making brick: soft-mud, dry-press, and stiff-mud. In 1964, one plant made soft-mud brick and three plants made dry-press brick, but in only one plant in each case was soft-mud brick and dry-press brick the major product. Twenty-three plants made brick by the stiff-mud method, and in eighteen of them stiff-mud brick was the major product.



MILNE 51338-4

Photo 8—Moulding brick by the dry-press method; Brampton Brick Limited, 1960. (Photo by Gilbert A. Milne and Co. Ltd., Toronto; courtesy Canadian Structural Clay Association, Willowdale.)

Photo 9—Making structural tile, using pug mill, stiff-mud auger extruder, and wire cutter; Natco Clay Products Limited. (Photo by James C. Fish, Burlington.)

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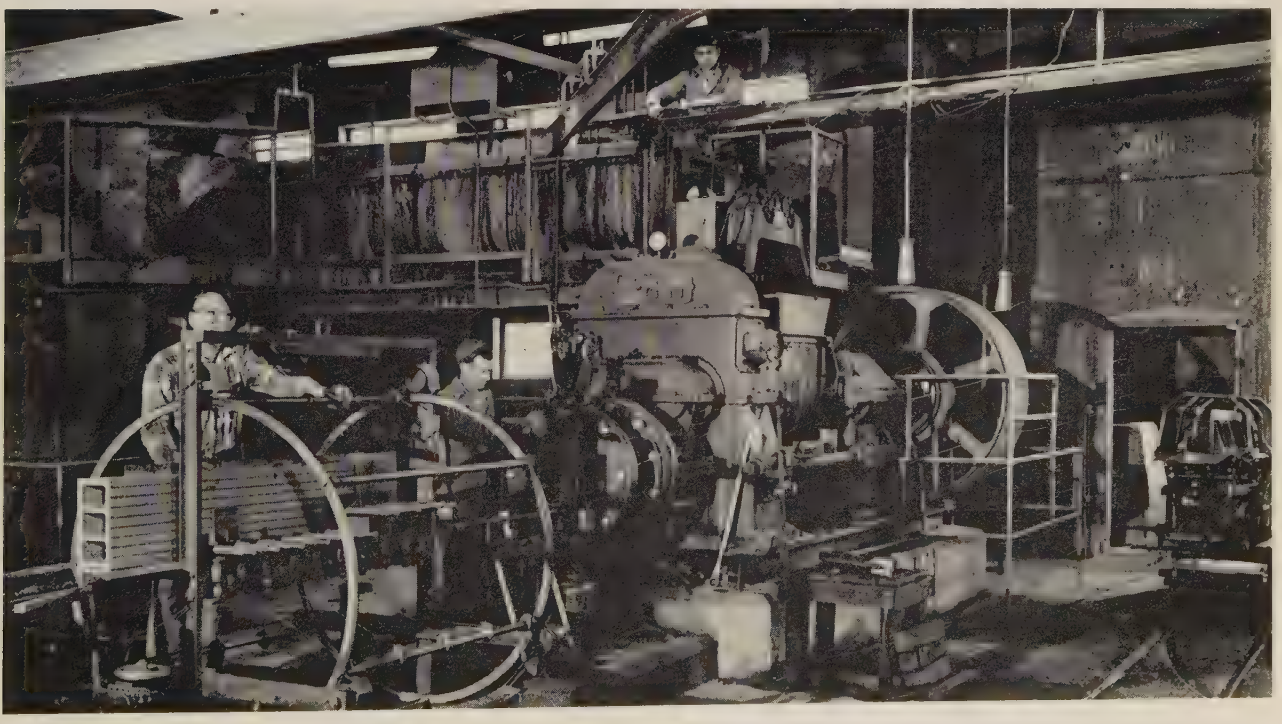


Soft-Mud Method. The soft-mud process requires a sandy clay, tempered with a large amount of water, so the batch will flow readily into sand-dusted wood moulds. Soft-mud machines make five bricks with each cycle and are capable of making 2,000 brick per hour. The method is essentially a refinement of the slop-mud process, whereby bricks are made by hand in individual wood moulds, a method that was still in use in a few brickyards in 1906 (Baker 1906, p. 44). Processes and equipment for soft-mud brick are described by Baker (1906, p. 44) and Montgomery (1930, pp. 55–58).

Dry-Press Method. Dry-press brick are usually made from ground shale, tempered with only a small amount of water. Bricks are formed under pressure in steam-heated steel moulds; pressure applied by an overhead steel plunger provides cohesion to the brick in lieu of sufficient water for plasticity. Dry-press machines make four to six bricks with each cycle, and are capable of making 2,000 brick per hour. Processes and equipment for dry-press brick are described by Baker (1906, p. 46), Keele (1924, p. 29), and Montgomery (1930, pp. 58–62).

Stiff-Mud Method. Stiff-mud brick are made with either clay or ground shale, tempered to a stiff consistency; more water is required than for dry-press brick, but less than for soft-mud brick. The batch is driven by an auger through a die, and bricks are cut from the extruded clay column. The process is continuous, and large auger machines are capable of producing more than 20,000 brick per hour. The stiff-mud process is described by Baker (1906, pp. 44–46), Keele (1924, p. 30), and Montgomery (1930, pp. 62–66).

TYPES OF BRICK

Dimensions of some of the bricks made in Ontario are given below. For general purposes almost all production, however, has been standardized to one size, known as "Ontario."

Ontario standard: 8⅜ × 4 × 2⅜
Canadian standard: 8 × 3¾ × 2¼
Modular: 7⅝ × 3⅝ × 2¼
Roman: 11⅝ × 3⅝ × 1⅝
Norman: 11⅝ × 3⅝ × 2¼
American: 4 × 3¾ × 2¼

In recent years glazed brick have become popular for commercial buildings. Toronto Brick Limited, pioneers in the development of glazed brick in Ontario, apply the ceramic glaze by spraying the exposed surfaces of an unfired shale brick. Research by the company was successful in matching the shrinkage and maturing properties of a boron glaze frit to that of the shale brick, so that a single-fire process could be used. Suitable metal oxides added to the frit provide a wide range of glaze colours. A general discussion of glaze application to structural clay products, and a description of an early two-fire process used by Toronto Brick Limited, is given by Groskaufmanis (1958).

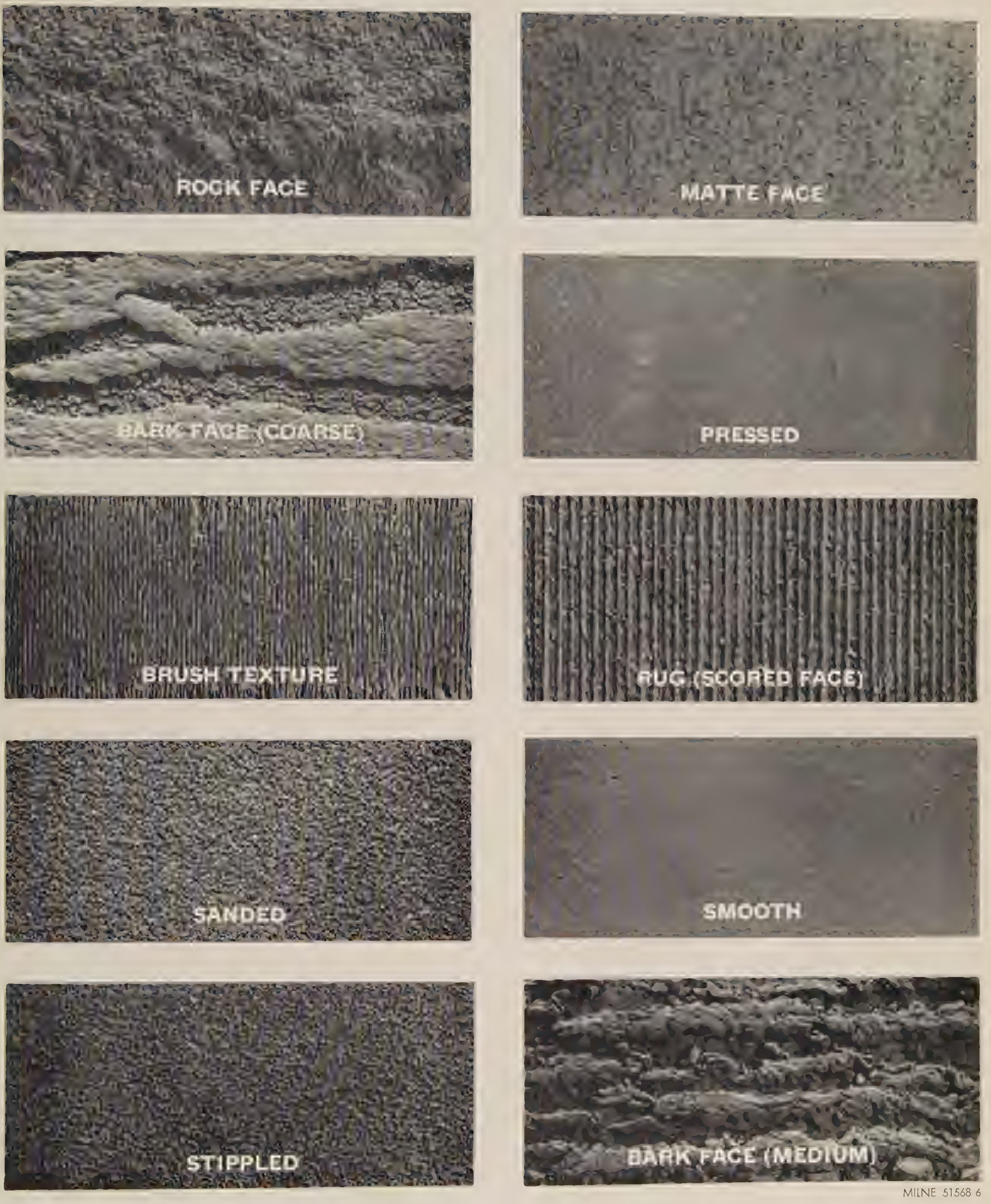
Paving brick and sewer brick are no longer important segments of the brick industry. In 1964 one plant reported minor production of paving brick, and three plants reported production of sewer brick. A description of the former Ontario Paving Brick Company is given by Baker (1906, pp. 112–114), and a short discussion on the requirements of paving brick clay, and the properties of the brick itself, are given by Keele (1924, p. 32).

SPECIFICATIONS FOR BRICK

Physical requirements as to strength, absorption, and durability of brick are outlined in a publication of the Canadian Standards Association entitled "Structural Clay Masonry Units." Specification A82.1–1954 of this publication gives the acceptable standards for building brick made from clay or shale. Specification A82.7–1954 pertains specifically to face brick. These specifications give the physical requirements of three grades of brick, as shown below. Grades SW and MW are face brick quality; grade NW is classed as common brick.

Standard methods of testing brick for compressive strength, water absorption, and resistance to freezing and thawing are detailed in specification A82.2–1954 of the Canadian Standards Association. The specification also gives the approved method for determining the modulus of rupture (flexure test), the initial rate of absorption (suction), efflorescence, size, and warpage.

GRADE SW: Brick intended for use where a high degree of resistance to frost action is desired and the exposure is such that the brick may be frozen when permeated with water.


ROCK FACE
MATTE FACE
BARK FACE (COARSE)
PRESSED
BRUSH TEXTURE
RUG (SCORED FACE)
SANDED
SMOOTH
STIPPLED
BARK FACE (MEDIUM)

MILNE 51568 6

Photo 10–Typical face-brick textures. (Photo by Gilbert A. Milne and Co. Ltd., Toronto; courtesy Canadian Structural Clay Association, Willowdale.)

GRADE MW: Brick intended for use where exposed to temperatures below freezing but unlikely to be permeated with water; or where a moderate and somewhat non-uniform degree of resistance to frost action is permissible.

GRADE NW: Brick intended for use as back-up or interior masonry.

TABLE 3 Physical Requirements for Brick

	Grade SW	Grade MW	Grade NW
Minimum compressive strength (brick flatwise) psi, gross area			
Average of 5 brick	3,000	2,500	1,500
Individual brick	2,500	2,200	1,250
Maximum water absorption by 5-hour boiling (*percent*)			
Average of 5 brick	17.0	22.0	no limit
Individual brick	20.0	25.0	no limit
Maximum saturation coefficient			
Average of 5 brick	0.78	0.88	no limit
Individual brick	0.80	0.90	no limit

Saturation coefficient is the ratio of absorption by 24-hour submersion in cold water to that after 5-hour submersion in boiling water.

If the average compressive strength is greater than 8,000 psi, or the average water absorption is less than 8.0 percent after 24-hour submersion in cold water, the requirement for saturation coefficient shall be waived.

Freezing-and-Thawing. The requirements specified for water absorption (5-hour boiling) and saturation coefficient shall be waived, provided a sample of five brick, meeting all other requirements, complies with the following requirements when subjected to 50 cycles of the freezing-and-thawing test:

GRADE SW: No breakage and not greater than 1.0 percent loss in dry weight of any individual brick.

GRADE MW: No breakage and not greater than 3.0 percent loss in dry weight of any individual brick.

Size Variation. A maximum variation of about three percent of the standard length of any dimension of the brick is permissible (clause 10, CSA spec. A82.1).

General Appearance. In addition to the foregoing requirements, CSA specification A82.7–1954 discusses texture and colour, chippage, and coring and frogging, with particular reference to face brick.

SCUM AND EFFLORESCENCE

Scum and efflorescence are closely related terms applied to unsightly white or light-coloured films deposited on the surface of clay or shale bodies. Scum usually refers to substances deposited during the drying or firing processes. Efflorescence refers to substances that appear after periods of exposure to the weather.

Causes. In Ontario, scum and efflorescence are commonly the result of minor amounts of gypsum ($CaSO_4 \cdot 2H_2O$) that occur in most shales and clays, but it may also be caused by sulphates of magnesium, iron, and alkalies, by certain chlorides, and by soluble vanadium and molybdenum compounds. Calcium sulphate is readily soluble in moisture absorbed by the brick, and is subsequently deposited by evaporation at the surface. Scum is also caused by sulphurous kiln gases forming sulphates with lime from the clay, and by reaction of sulphide minerals such as pyrite (FeS_2) with carbonate. Efflorescence may also be due to soluble salts contained in mortar used with the brick in construction.

Controls. Searle and Grimshaw (1959, p. 833) suggest the following ways to prevent or reduce scum and efflorescence:

1. By adding barium carbonate or chloride to the clay; this converts any soluble sulphates into insoluble barium sulphate and renders them harmless. This treatment is not effective for other salts which cause efflorescence.
2. By maintaining oxidizing conditions during the initial stages of burning and reducing the sulphur content of the kiln gases to a minimum.
3. By avoiding the use of water or mortar containing soluble salts.
4. By avoiding contamination of the material at all stages of manufacture.
5. By painting the surface of brickwork with a

solution of silicone or other organic silicate compound. Although this is an expensive method it is most effective.

The causes and methods of controlling efflorescence are discussed in a paper by Graham (1954). The standard method of testing brick for efflorescence is given in CSA specification A82.2.

SEWER BRICK

Specification C32 of the American Society for Testing and Materials (ASTM) outlines the requirements for sewer brick found in Table 4.

TABLE 4 Requirements for Sewer Brick

	Grade SA	Grade MA	Grade NA
Minimum compressive strength (brick flatwise) psi, average gross area			
Average of 5 brick	8,000	5,000	2,500
Individual brick	5,000	3,000	2,200
Maximum water absorption by 5-hour boiling (percent)			
Average of 5 brick	6	12	22
Individual brick	9	16	25

Where resistance to frost action is important, grades MA and NA shall have saturation coefficients not exceeding 0.80, except where the average compressive strength is greater than 8,000 pounds per square inch, or average water absorption by 5-hour boiling is less than 8.0 percent, in which case the saturation coefficient shall be ignored.

PAVING BRICK

Specification C7 of the American Society for Testing and Materials (ASTM) outlines the following requirements for abrasion resistance for paving brick. Abrasion is measured by the Rattler test, which involves the revolving of 10 brick with iron spheres in an iron barrel for 1,800 revolutions at 30 r.p.m.

$$\text{Percent loss} = \frac{\text{original weight} - \text{final weight}}{\text{original weight}} \times 100$$

Maximum permissible loss in weight for various brick sizes is set out in Table 5.

TABLE 5 Abrasion Limits for Paving Brick

Size of brick: transverse dimensions (*inches*)	Length (*inches*)	Maximum loss in Rattler test (*percent*)
$2\frac{1}{2} \times 4$	$8\frac{1}{2}$	26
3×4	$8\frac{1}{2}$	24
$3\frac{1}{2} \times 4$	$8\frac{1}{2}$	22

BRICK PRICES

In the early 1960's face brick were valued at $40–60 per thousand at the plant. Common brick were valued at about half that of face brick, while glazed brick sold for about twice the face brick price. The total volume and value of the various brick types sold in Ontario during 1964 has been indicated already (see Table 2, p. 8).

Drain Tile

Tile is used for drainage for both residential and agricultural purposes. The principal market is agricultural, where improved crop yields have established the value of field drainage.

The growth of the drain tile industry has saved rural brick producers from gradual extinction. The small simple plants of many former clay-brick producers have difficulty in competing in quality and price with brick produced from the large modern shale-brick plants. Limiting specifications for absorption are lacking for tile, and the colour of the fired tile is not significant, so the limy clays prevalent throughout much of Ontario are an adequate raw material. The widespread agricultural market for tile is efficiently served by small scattered plants producing for local markets.

FIELD DRAIN TILE

Drainage lengthens the growing period by permitting cultivation of the ground about two weeks earlier in the spring than with undrained land. It increases crop yields in wet seasons by removing surplus

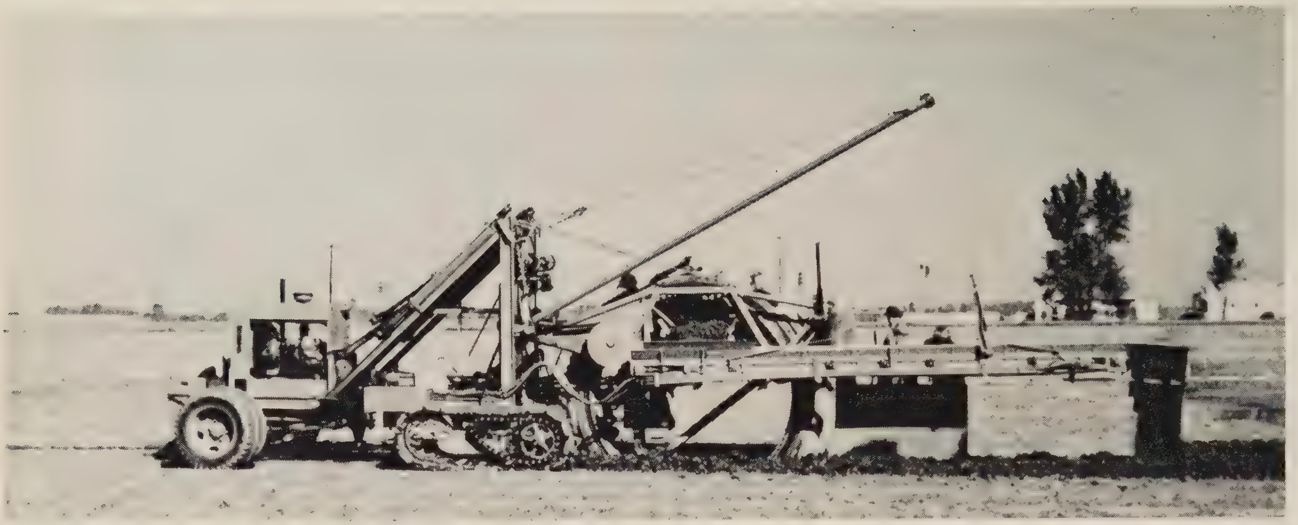


Photo 11—Modern trenching and tile-laying equipment at work in Essex county.

moisture, and benefits crops in dry seasons by encouraging deeper root systems. Tile drainage is preferable to drainage by surface ditching because it results in less loss of soil material and plant food. The Ontario Agricultural College estimates that 9.1 million acres of the 13.0 million acres of land suitable for agricultural use in Ontario suffers from inadequate drainage (Hoffman, Matthews, and Wicklund 1964, p. 8).

Producers of drain tile benefit from the Ontario Government's Tile Drainage Act, which permits farmers to borrow up to 75 percent of the cost of the drainage work at an interest rate of 4 percent. Moreover the Ontario Department of Agriculture will carry out the survey work necessary for an effective drainage system without charge (Irwin 1963, pp. 2–3).

Tile drainage is outlined in a number of publications of the Ontario Department of Agriculture, obtainable from the Parliament Buildings, Toronto.

Publication no. 4: *Farm tile drainage assistance*
Publication no. 29: *Drainage guide for Ontario*
Publication no. 36: *Laying tile by hand*
Publication no. 501: *Farm drainage*

Modern tiling practice makes use of continuous excavators having bucket-scoops attached to a revolving wheel or chain belt. Parallel drain lines are normally spaced 40–50 feet apart in clay soils, 50–70 feet in sand or loam soils. Depths vary from 2 to 3½ feet. Tile are placed end to end as close together as possible in sand and loam soils, but may be spaced ⅛–¼ inches in clay soils. Water enters the tile through the joint, not through the tile wall.

TILE SIZES

Tile are made with diameters ranging from 3 to 16 inches. Smaller tile are made in 12-inch lengths, larger ones sometimes in greater lengths. Many producers only make 4 or 5 sizes in the popular 4 to 8-inch diameter range. Feeder lines for field drainage are almost always made with 4-inch tile; larger tile are used for trunk or collector lines.

SPECIFICATIONS

Specifications for drain tile are to conform to the requirements established by the American Society for Testing and Materials (ASTM). The tile should be straight and approximately circular in cross-section. The ends should be regular and smooth, the inside surface should be smooth, and the tile should be free from cracks, broken pieces, and checks which would decrease the strength or admit soil into the drain.

For tile 4–12 inches in diameter the specifications call for a minimum crushing strength of 800 pounds per lineal foot for the average of 5 tile, and a minimum of 680 pounds per lineal foot for any individual tile. Limits on water absorption are not apparently enforced in Ontario, but ASTM designates a maximum water absorption by 5-hour boiling of 13 percent for the average of 5 tile, and an individual maximum of 16 percent. This absorption requirement shall, however, be waived if in a sample of 5 tile no individual tile shows a loss of weight due to disintegration or spalling in excess of 5 percent of its dry weight after subjection to 36 cycles of the freezing and thawing test.

PRODUCTION

The annual production of the tile industry for the 20-year period 1944–1964 has been traced in Table 1 (p. 7). Most tile producers have been working at maximum capacity during recent years, and the high level of production is expected to continue. Prices for 4-inch tile are quoted at $50–60 per thousand at the plant.

Sewer Pipe

Development of a sewer pipe industry in Ontario has been hampered by the scarcity of suitable local clays. Red clay derived from eroding Queenston shale at Aldershot and Hamilton is still the only known clay in southern Ontario that has been proven suitable.

In recent years this clay has been blended with imported fireclay, but reserves of the Aldershot clay are now all but exhausted, or unavailable for use as a result of urban development.

Sewer pipe clays must be plastic and tough, have a high green and dry strength, and vitrify to a strong dense body. A long vitrification range and a high resistance to warping is desirable. Formerly it was also necessary that the clay have certain chemical and physical characteristics that would permit it to take a salt glaze. In recent years the salt glaze was replaced by a ceramic glaze, but currently no glaze is used at all.

National Sewer Pipe Limited operates plants at Clarkson and Hamilton using a blend of Aldershot clay and imported fireclay and shale. Only the Clarkson plant now makes sewer pipe; the pipe are produced in diameters from 4 to 27 inches, 3½–5 feet in length. Couplings for the pipe are also made. National Sewer Pipe Limited was formed by amalgamation of four separate companies in 1928; descriptions of these companies are given by Montgomery (1930, pp. 12 and 168–170). Canada Vitrified Products Limited uses the same Aldershot clay and imported clay and shale at its sewer pipe plant in St. Thomas.

Sewer pipe and fittings must conform to the requirements of specification A60–53 of the Canadian Standards Association (CSA). Strength requirements are given by specifications C13, C261, C200, and C278 of the American Society for Testing and Materials (ASTM). Most specifications designate a maximum water absorption of 8 percent. Tolerance limits for pipe sizes, and acid resistance, are also specified.

Structural Tile

Four plants reported production of structural tile in 1964. Natco Clay Products Limited, established in 1910 under the name of National Fireproofing Company of Canada, has been a producer of structural tile exclusively from the beginning. It now produces some drain tile in addition to about 50 different sizes and shapes of structural, partition, and fireproofing tile. Domtar Construction Materials Limited at Cooksville has also had a substantial production of structural tile for many years, operating at an early date under the name of the Cooksville Company.

TABLE 6 Load-bearing Wall Tile
(CSA specification A82.4–1954)

	Grade LB X	Grade LB
Maximum water absorption by 1-hour boiling (*percent*)		
Average of 5 tests	16	25
Individual	19	28
Minimum compressive strength psi, gross area		
End-construction tile		
Average of 5 tests	1,400	1,000
Individual	1,000	700
Side-construction tile		
Average of 5 tests	700	700
Individual	500	500

GRADE LB X: Suitable for general use in masonry construction and adapted for use in masonry exposed to weathering, provided they are burned to the normal maturity of the clay. They may also be considered suitable for the direct application of stucco.

GRADE LB: Suitable for general use in masonry where not exposed to frost action, or for use in exposed masonry, where protected with a facing of 3 inches or more of stone, brick, terra cotta, or other masonry.

Table 7 Floor Tile and Facing Tile

	Grade I	Grade II	Standard	Special Duty
Maximum water absorption (%)				
Floor tile (ASTM #C57)				
One-hour boiling				
Individual	25	25		
Facing tile (ASTM #C212)				
24-hour cold water				
Average	7	13		
Individual	9	16		
One-hour boiling				
Average	9	16		
Individual	11	19		
Minimum compressive strength psi*				
Floor tile (ASTM #C57)				
End-construction				
Average of 5 tests	3,200	2,000		
Individual	2,250	1,400		
Side-construction				
Average of 5 tests	1,600	1,200		
Individual	1,100	850		
Facing tile (ASTM #C212)				
End-construction				
Average of 5 tests			1,400	2,500
Individual			1,000	2,000
Side-construction				
Average of 5 tests			700	1,200
Individual			500	1,000

*Compressive strength based on gross area.

Because of the many sizes, shapes, and uses for structural tile, specifications as to over-all dimensions, numbers of cells (hollow spaces), shell and webb thickness, and exterior finish are numerous. The reader is referred to specifications A82.4–1954 and A82.5–1954 of the Canadian Standards Association (CSA) for such details in regard to load-bearing and non-load bearing tile respectively. The American Society for Testing and Materials (ASTM) outlines the physical specifications for floor tile (Spec. C57) and facing tile (Spec. C212).

Limiting specifications for strength and absorption for the principal structural tile types are reproduced in Tables 6 and 7.

For non-load-bearing tile, absorption by 1-hour boiling for any individual tile shall not exceed 28 percent (CSA. spec. A82.5–1954).

Expanded Aggregate

The use of expanded clay or shale as concrete aggregate, in place of sand, gravel, or crushed stone, is steadily increasing. Expanded clay or shale used in concrete blocks and precast concrete shapes is effective in reducing weight at a small loss in strength.

Expanded clay or shale is a medium weight aggregate, having a bulk density of 40–60 pounds per cubic foot. Sand, gravel, and crushed stone have bulk densities of 90–120 pounds per cubic foot, and the lightweight aggregates, perlite and vermiculite, weigh 6–16 pounds per cubic foot. Expanded blast furnace slag has about the same bulk density as expanded clay and shale. The relative properties of the common aggregate materials are given by Matthews (1951, pp. 489–490).

Two types of expanded clay or shale aggregates are possible: coated aggregates and sintered aggregates. Coated aggregates are rounded cellular particles enclosed in smooth hard shells. Bloating has occurred before fusion is complete and so the product is discharged as individual particles requiring a minimum of crushing. Such a product is preferred, as the sealed particles are less absorptive and easier to mix in the concrete batch. Sintered aggregates are discharged as a cellular clinker that requires crushing and screening to produce a graded product. Sintered aggregates can be made from naturally bloating materials and, by pelletizing with a suitable fuel, non-bloating materials.

The requirements of a natural bloating clay or shale are outlined by Wilson (1962, pp. 3–4) thus:

> It must contain a combination of fluxes that will develop a viscous glass when heated to a point of incipient fusion. Also it must contain a mineral or minerals that will dissociate when the material is in the viscous state and release a gas or gases. If these conditions exist, the gases will be entrapped within the glass formed, and the particles of clay or shale will expand or bloat. The raw materials should also have a fairly wide vitrification range in order that the temperature fluctuations within the kiln will not have too marked an effect on the product. It is difficult to maintain the temperature within limits of less than about 50 degrees. One of the troublesome components of clays and shales, particularly those found in Ontario and Quebec, is lime in the form of calcite. A small quantity is desirable, for it acts as both a flux and a gas-producing agent. In larger quantities, however, the fluxing action is excessive, and a small increase in temperature above that at which vitrification has begun will result in extensive fusion. This is caused by the formation of glass of low viscosity.

PROCESSING

Expanded clay or shale can be produced in either a rotary kiln or a travelling-grate type sintering machine. Wilson (1962, pp. 5–7) describes the process as follows:

> [The Rotary Kiln Process]. All Canadian plants producing lightweight aggregate from clay or shale use the rotary kiln process. The kilns vary in length from 50 to 160 feet, and in diameter from 6 to 10 feet. Production varies from 5 to 15 cubic yards per hour, depending on the kiln. Some of the more efficient plants use a rotary cooler to cool the aggregate and, at the same time to preheat air for combustion. One plant makes use of a rotary dryer to preheat the raw material. The more efficient plants consume about 2 million Btu of heat per cubic yard of aggregate produced. . . .
>
> [The Travelling-grate Sintering Process]. This process has been adapted from the metallic-ore-processing industry, in which it is used to agglomerate finely-sized ore, or to drive off undesirable volatile components of the ore. In the lightweight aggregate industry, a much wider range of raw materials can be processed by sintering than by the rotary kiln process, because the raw material does not have to bloat. In fact, it is probably more desirable if it does not bloat appreciably. The raw material, usually crushed to about minus ⅜ inch, is mixed with 5 to 10 percent minus 3/16 inch low volatile fuel, such as coke or anthracite coal, and pelletized. This agglomerates the finely-sized material. The pelletized mixture is placed as a porous bed on a sintering machine, the most common of which is the travelling-grate type. The bed of material passes first under an ignition hood, where the fuel at the surface is ignited. Following this, it progresses over a series of wind boxes which draw a large quantity of air down through the bed. This gradually moves the zone of ignition down until the material has sintered to a porous clinker. The clinker, when cooled, is crushed to aggregate size.

PRODUCTION

Expanded Dundas shale, under the name Haydite, has been produced at Cooksville since 1928. It is a naturally bloating sintered product made by the rotary kiln method. Haydite production is integrated with brick and tile production by Domtar Construction Materials Limited; the Haydite plant is described on pages 42 to 44.

Blast furnace slag from the Hamilton foundaries of Dominion Foundries and Steel Limited, and the Steel Company of Canada Limited, is processed by National Slag Limited. The molten slag is expanded by the evolution of steam when water is added. The cellular clinker is crushed to aggregate sizes.

The Canadian production of expanded domestic clays and shales was 482,488 cubic yards in 1964, an increase of 10 percent over 1963; the value of this production was $2,558,474. Production of expanded slag in 1964 was 286,840 cubic yards valued at $688,834. Prices for expanded clay and shale aggregates are $4.50–$6.00 per cubic yard at the producing plant; $2.35–$3.85 for expanded slag (Wilson 1965).

TESTING ONTARIO CLAYS AND SHALES FOR EXPANDED AGGREGATE

Many Ontario clay and shale deposits have been tested for expanded aggregate by the Mines Branch, Department of Mines and Technical Surveys, Ottawa. The reader is referred to reports by Matthews (1952) and Wilson (1963) for the results of this testwork. Samples taken during the present survey were not evaluated for expanded aggregate.

In general, Dundas shale bloats well before the point of fusion but coated aggregates have poor particle shape (slabby, rather than rounded). A crushed sintered product made in rotary kilns is produced at Cooksville. Some sections of Queenston shale exhibit moderate to good bloating characteristics almost at the point of fusion. The shale is unsuited for coated aggregate but would make a sintered product in a travelling-grate type machine. Some sections of the Hamilton shale show promise of making a good quality coated aggregate; other sections are poor.

The only clays suitable for coated aggregate are located in extreme southwestern and southeastern Ontario. The stoneless top 3 feet of a till which is widespread in Essex and Kent counties are generally excellent, becoming less so northward through Lambton county. Marine clays in the St. Lawrence valley show promise of value for coated aggregate, but northward in the Ottawa valley they are generally poor. Glacial and interglacial clays of the Toronto region and clays north of Lake Ontario and Lake Erie are not suited for coated aggregate. The same applies to scattered clay occurrences on the north shore of Lake Huron from Sudbury to Sault Ste. Marie. Red Aldershot sewer pipe clay is poorly suited for coated aggregate.

Clay Technology

Heavy clay products are made from naturally occurring materials in which clay minerals form a significant part. Clay minerals are secondary minerals formed by the chemical weathering of aluminous minerals such as feldspar or mica, thus:

$K_2O \cdot Al_2O_3 \cdot 6SiO_2 \rightarrow$
orthoclase feldspar
$Al_2O_3 \cdot SiO_2 \cdot 2H_2O + 4SiO_2 + 2KOH$
kaolinite clay

Clay minerals are distinctive because of their extremely fine crystallization, commonly less than 2 microns, and by the plasticity they exhibit as a wet mass. Most clay materials also contain sand or silt, and organic debris, to a greater or less extent. "Lean" clays are usually silty or sandy and have low to moderate plasticity. "Fat" clays are smooth and greasy when wet, and have high plasticity.

Most Ontario clay deposits are composed of soft unconsolidated mixtures of clay minerals and non-clay materials deposited during the last million years and occurring at or near the surface. Geologically, these clays were formed during the Wisconsinan glacial stage, or the Sangamonian or Recent interglacial stages, of the Pleistocene epoch. High-quality ceramic clays (fireclay and china clay) are known only in a restricted portion of the James Bay lowland; they were formed during the Cretaceous period 100 million years ago.

Shales of Ontario are generally similar in composition to the Pleistocene clays, but they have been rendered hard and dense by compaction since their deposition as clay more than 350 million years ago. Shales used for heavy clay products in Ontario were formed during the Ordovician and Devonian periods of the Paleozoic era.

CLAY MINERALS

Clay minerals are essentially hydrous aluminium silicates. There are three major groups to which the clay minerals belong: the kaolinite group, the montmorillonite group, and the illite group. The true clay minerals, plus the closely related mica, chlorite, serpentine, and vermiculite minerals, are composed of two structural units known as the silica sheet and the gibbsite sheet. The silica sheet is a continuous structure formed by linking silica tetrahedrons [SiO_4^{4-}] indefinitely in two dimensions. The gibbsite sheet is a continuous structure formed by linking octahedral units of aluminium and hydroxyl ions [$Al(OH)_3$]. Individual minerals differ in the ways in which these sheets are stacked one above the other, and by chemical variations caused by ionic substitution. Because the bonds between the sheets are weak the minerals have a platy habit and an excellent basal cleavage.

Minerals of the kaolinite group include kaolinite, dickite, nacrite, livesite, and halloysite. Those associated with the montmorillonite group include pyrophyllite, talc, nontronite, montmorillonite and beidellite. Bentonite is composed of several members of the montmorillonite group. The illite minerals are a poorly defined group of mica-like minerals with widely varying compositions.

Illite is the dominant clay mineral in the shales and Pleistocene clays of Ontario. Montmorillonite is usually present in the clays in minor to moderate amount, but kaolinite is rarely detected because it will not form in a limy environment (Grim 1953, pp. 353–355). Kaolinite is only found in abundance in the Cretaceous clays of the James Bay lowland. As a result of metamorphic alteration montmorillonite is generally absent in sediments older than the Mesozoic, and kaolinite is scarce in sediments older than the Devonian (Grim 1953, pp. 356–357): thus illite, commonly associated with a moderate amount of chlorite, is the principal clay mineral present in the shales of Ontario.

NON-CLAY MATERIALS

Clay and shale deposits rarely consist only of clay minerals. Non-clay materials may amount to more than half of a deposit. The clays and shales of Ontario contain an average of 60 percent clay and clay-like minerals. (Chlorite and vermiculite are usually included in the clay fraction.) The remaining 40 percent consists of non-clay minerals (quartz, calcite, dolomite, feldspar, iron oxides, and dark minerals) and organic material.

The common effect of the non-clay minerals is toward reducing the plasticity of the mass. For heavy clay products, non-clay materials must be added to the batch if the clay fraction, and hence the plasticity, is too high. The usual additive is sand. Ground and screened cull brick (known as "grog") may also be used. Quartz [SiO_2] is the most common non-clay mineral in clays and shales; it is not deleterious except to the extent that if present in excessive amounts it may reduce the plasticity of the batch below a desirable minimum.

Calcite [$CaCO_3$] and dolomite [$Mg\ Ca(CO_3)_2$] are probably the most objectionable non-clay minerals. They contribute to an open porous structure in the fired body, shorten the firing range, and tend to produce a buff-fired colour. Limestone (predominantly $CaCO_3$) or lime [CaO] is sometimes added to a red burning clay to produce a buff brick. Bell (1965) has investigated in some detail the thermal expansion of clays and shales due to the influence of lime. In some cases cracking has occurred in high lime brick during the cooling cycle following firing. Failure may also occur when pebbles or fragments of limestone are converted to lime during firing; they subsequently absorb moisture to form slaked lime [$Ca(OH)_2$] with an increase in volume that may rupture the ware. Lime "pops" resulting from limestone pebbles, that are a common feature of many Ontario clays, make it necessary to either eliminate such pebbles or grind them to a state of fineness at which the volume expansion will not be sufficient to cause destruction of the ware. Calcite is also objectionable if pyrite [FeS_2] is present, as the two may combine to form a calcium sulphate scum.

Feldspar is not objectionable, and is effective mainly as a non-plastic ingredient. In clays more refractive than the common Ontario clays and shales feldspar acts as a flux, reducing the temperature of vitrification.

Iron-bearing minerals in clays and shales commonly occur as grains of magnetite [Fe_3O_4], hematite [Fe_2O_3], scales or films of limonite [hydrous iron oxide], pyrite [FeS_2], and occasional grains of ferromagnesian minerals of the pyroxene and amphibole groups. Iron-bearing minerals may reduce the vitrification temperature of some clays, but their main influence is in the colour of the fired ware: red under normal oxidizing conditions; black in a reducing atmosphere.

Organic matter is especially common in Recent clays, occurring principally in the form of plant debris. All carbonaceous matter will burn out at a low temperature with no deleterious effect provided the evolution of carbon dioxide is not inhibited. If the rate of heating is too great, partial fusion of the surface of the ware may prevent complete expulsion of the gas, resulting in bloating and "black-coring."

Shells in Recent clays, and fossils in older sediments, behave in a similar way to fragments of calcium carbonate; unless eliminated or finely-ground they may produce lime "pops" in the fired ware.

PHYSICAL PROPERTIES OF CLAY

The commercial value of a clay or shale depends mainly on its physical properties. Properties of prime importance in evaluating a clay material are:

Plasticity. Plasticity is the property of a moist clay to change form under pressure without rupturing and to retain that form on release of pressure. The relative plasticities of various clays is usually proportional to the amount of water required to render the clays plastic (i.e. water of plasticity). The terms "workability" and "plasticity" are analogous, workability" often being used to refer to the ease with which a clay can be formed in commercial processes.

Strength. The strength (green strength) of a moist clay must be sufficient to permit handling of the formed ware without deformation.

Shrinkage. Drying shrinkage refers to the contraction of a clay from a plastic condition to that of a dry rigid solid. Firing shrinkage is the further contraction of the clay that normally occurs during firing. However, some limy clays may expand on firing.

Vitrification range. The range of temperature between the point where fusion begins and the point where the body no longer retains its shape through flowage is known as the vitrification range. It is desirable to have as long a vitrification range as possible, otherwise firing conditions become very critical; a range of 50°F is about minimum for heavy clay products.

Refractoriness. Refractoriness is the degree to which a clay is able to withstand high temperature without failure. The refractoriness, or fusibility, of the clay is usually given in terms of its pyrometric cone equivalent (P.C.E.). Cones are a convenient method of relating temperature and time, both of which influence the firing behaviour of ceramic materials. The refractoriness of a sample is defined as the cone number of the standard that most nearly duplicates the fusibility of the test sample.

Fired colour. Colour of the fired clay bears little relation to its raw colour, but is related to either the chemical composition of the clay or the kiln atmosphere, or both.

Porosity. Porosity refers to the volume percentage of voids remaining in the fired body.

Absorption. Absorption refers to the percentage of water that can be absorbed by the fired body. Absorption is usually measured both after 24 hours soaking in cold water and after 5 hours in boiling water. Low absorption is desirable for increased resistance to weathering and discolouration.

EFFECT OF HEAT ON CLAY

Although it is possible to discuss the behaviour of clays through various temperature ranges, it is not possible to assign a precise temperature to a single event unless "time" conditions are also defined. The firing properties of all ceramic materials are related to both temperature and time. The effect produced on a clay that has been exposed to a certain temperature for a short time might be the same effect that would be produced after long exposure to a lower temperature.

Pyrometric Cones

Pyrometric cones are a convenient method of relating temperature and time by a single value. For any given cone number a precise temperature can be given only when the heating rate is maintained at 150°C (270°F) per hour (up to cone 12). In the example given in the previous paragraph the cone number would remain the same under both time-temperature conditions.

Cones are 5cm. in height, with a base that is an equilateral triangle 1.5 cm on a side. One vertical edge of the cone is at right angles to the base, displacing the centre of gravity to one side; when fusion commences the tip of the cone bends in the predetermined direction. Standard cones are moulded or cut from various ceramic mixtures having bending temperatures at the intervals shown in Table 8.

Cones are used in kilns, usually in conjunction with thermo-electric and optical pyrometers, to mark the end points in firing schedules. They are also used in determining the refractoriness, or pyrometric cone equivalent (P.C.E.), of ceramic materials by a comparative method.

FIRING STAGES OF A CLAY

Firing of clay products can be discussed under four headings: Dehydration, Oxidation, Vitrification, and Fusion.

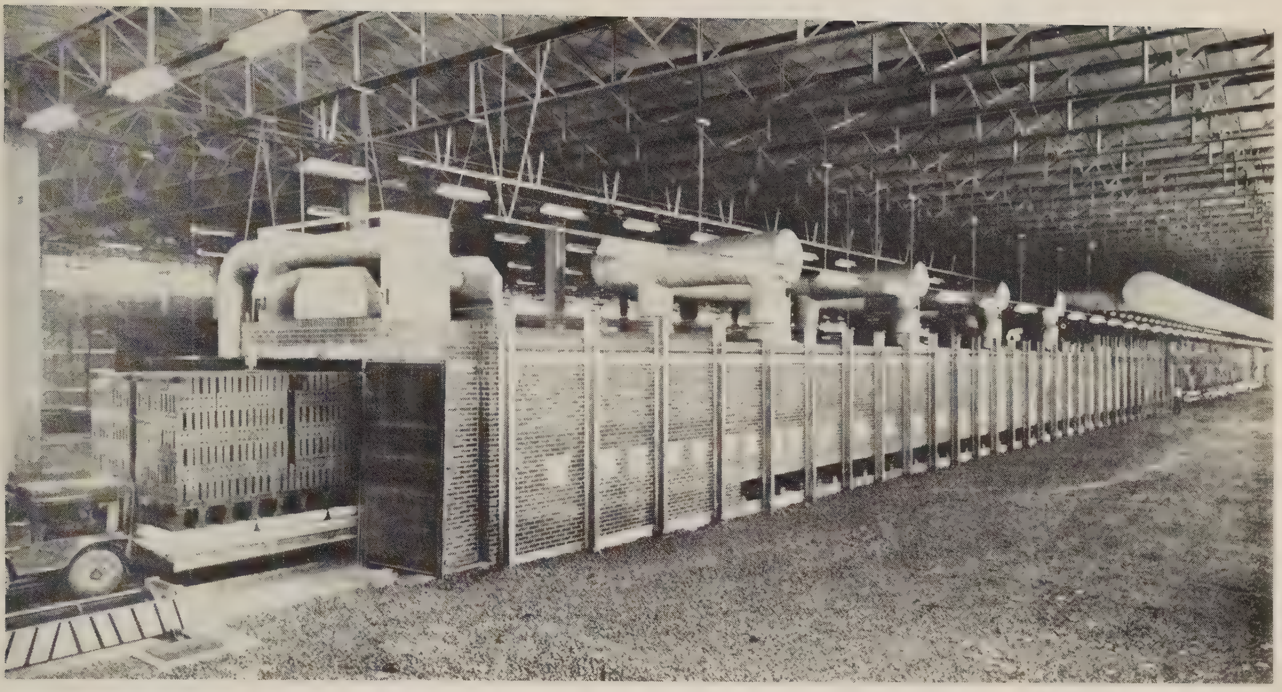
Dehydration. Dehydration, or "water-smoking," involves the elimination of water. Free water, or moisture, is driven off in the temperature zone 70° to 300°F. Water combined chemically in the hydrous minerals is evolved between 300°F and 1100°F.

Oxidation. Oxidation normally is completed in the temperature zone 650° to 1750°F. Organic materials are burned, and carbonates, sulphides, and sulphates are decomposed. The principal gases evolved are carbon dioxide, sulphur dioxide, and sulphur trioxide. It is important that the rate of heating during this period be carefully controlled to insure complete oxidation of carbon before partial fusion of the clay surface prevents the escape of carbon dioxide. Bloating caused by bubbles of trapped gas, and "black-coring" caused by unoxidized carbon, may be the result of too fast a heating schedule.

Vitrification. Vitrification is the condition of partial fusion, whereby a glassy bond is formed around predominantly unfused particles, resulting in increased hardness and decreased porosity and volume. Vitrification of common clays and shales may begin as low as 1650°F and continue to the softening point.

TABLE 8 Temperature Equivalents, Orton Standard Pyrometric Cones
(heating rate: 150°C (270°F) per hour)

Cone Number	Temperature Equivalents		Cone Number	Temperature Equivalents		Cone Number	Temperature Equivalents	
010	894°C	1641°F	02	1120°C	2048°F	6	1222°C	2232°C
09	923°C	1693°F	01	1137°C	2079°F	7	1240°C	2264°F
08	955°C	1751°F	1	1154°C	2109°F	8	1263°C	2305°F
07	984°C	1803°F	2	1162°C	2124°F	9	1280°C	2336°F
06	999°C	1830°F	3	1168°C	2134°F	10	1305°C	2381°F
05	1046°C	1915°F	4	1186°C	2167°F	11	1315°C	2399°F
04	1060°C	1940°F	5	1196°C	2185°F	12	1326°C	2419°F
03	1101°C	2014°F						



CSCA-4

Photo 12—Firing brick in a modern continuous-tunnel kiln. (Photo courtesy Canadian Structural Clay Association, Willowdale.)

The softening point is the stage at which sufficient fusion has occurred to cause deformation.

The degree of vitrification of a clay body is indicated by its porosity, volume shrinkage, hardness, and depth of colour. Stoneware clays vitrify to a dense, hard, body of low porosity, but most Ontario clays and shales deform before they are completely vitrified. Many limy clays do not vitrify at all but rather tend to expand and become more porous up to the point of softening.

Fusion. Fusion is defined as the change of state of a substance from the solid to a liquid phase. In most ceramic materials fusion takes place over a considerable range of temperature. The range of partial fusion before deformation is known as the vitrification range. In the firing of heavy clay products fusion is considered to be the point where deformation occurs. In addition to warpage of the ware, fusion is indicated in red-burning clays by increased shrinkage, density, and depth of fired colour; a dark red or mahogany brown colour with a smooth, or sometimes blistered, hard glassy surface is typical. Fusion of limy clays occurs rather suddenly and is marked by warpage, increased density and shrinkage, and often by a greenish cast on the yellow fired colour.

Prospecting for Clay and Shale

In prospecting for clay and shale deposits in Ontario a knowledge of Pleistocene and Paleozoic geology is important. Land formerly inundated by the glacial forerunners of our present Great Lakes is a prime area for deposits of stoneless clay. So too are the ponds and flood plains that were temporarily developed along the melting ice-fronts. Older sedimentary rocks that underlie glacial deposits throughout much of southern Ontario are tilted towards the southwest. A knowledge of the outcrop areas of the shale formations contained within this sequence of Paleozoic rocks will greatly limit the area of search for shale deposits.

MAPS AND REPORTS

Much of Ontario has now been covered by government geological surveys. Geological reports and maps useful in prospecting for clay or shale are available for some areas. The results of surveys in specific areas describing surficial or Pleistocene deposits, and others describing Paleozoic rocks and the principal shale formations, may be obtained from the Geological Survey of Canada (Canada Dept. Energy, Mines, and Resources), Ottawa, or the Ontario Department of Mines, Toronto.

The maps accompanying the book by L. J. Chapman and D. F. Putnam, *The Physiography of Southern Ontario* (University of Toronto Press, 1951), are especially useful references to the surficial deposits of southern Ontario. Also useful are the soil survey maps produced jointly by the Canada Department of Agriculture and the University of Guelph. Soil survey reports are now available for most of the counties in southern Ontario. Memoir 142, *Preliminary report on the clay and shale deposits of Ontario* by J. Keele (Geological Survey of Canada, 1924) is still a most useful reference.

The following is a partial list of government publications that may be useful in prospecting for clay or shale deposits in specific areas.

Clay Deposits

Coleman, A. P.

1933: *The Pleistocene of the Toronto region*, Ontario Dept. Mines, Vol. 41, 1932, Pt. 7.

1937: *Lake Iroquois*, Ontario Dept. Mines, Vol. 45, 1936, pt. 7.

Deane, R. E.

1950: *Pleistocene geology of the Lake Simcoe District, Ontario*, Geol. Surv. Canada, Memoir 256.

Dreimanis, A.

1964: *Pleistocene geology of the St. Thomas area (west half)*, Ontario Dept. Mines, Prelim. map No. 238.

Gadd, N. R.

1963: *Surficial geology of Ottawa map-area, Ontario and Quebec*, Geol. Surv. Canada, Paper 62-16.

Gravenor, C. P.

1957: *Surficial geology of the Lindsay-Peterborough area*, Geol. Surv. Canada, Memoir 288.

Hughes, O. L.

1956: *Surficial geology of Smooth Rock, Cochrane District, Ontario*, Geol. Surv. Canada, Paper 55-41.

1959: *Surficial geology of Iroquois Falls, Cochrane District, Ontario*, Geol. Surv. Canada, Map 46–1959.

1960: *Surficial geology of Kirkland Lake, Timiskaming and Cochrane Districts, Ontario*, Geol. Surv. Canada, Map 1–1960.

Johnston, W. A.

1915: *Rainy River district, Ontario: Surficial geology and soils*, Geol. Surv. Canada, Memoir 82.

1917: *Pleistocene and Recent deposits in the vicinity of Ottawa*, Geol. Surv. Canada, Memoir 101.

Karrow, P. F.

1963: *Pleistocene geology of the Hamilton-Galt area*, Ontario Dept. Mines, Geol. Report No. 16.

1967: *Pleistocene geology of the Scarborough area*, Ontario Dept. Mines, Geol. Report No. 46.

Owen, E. B.

1951: *Pleistocene and Recent deposits of the Cornwall-Cardinal area, Stormont, Dundas, and Grenville counties, Ontario*, Geol. Sur. Canada, Paper 51-12.

Terasmae, J.

1960: *Surficial geology of the Cornwall map-area*, Geol. Surv. Canada, Paper 60-28.

Terasmae, J. and Hughes, O. L.

1960: *A palynological and geological study of Pleistocene deposits in the James Bay lowlands, Ontario*, Geol. Surv. Canada, Bull. 62.

Watt, A. K.

1957: *Pleistocene geology and ground-water resources of the township of North York, York county*, Ontario Dept. Mines, Vol. 64, 1955, pt. 7.

Zoltai, S. C.

1961: "Glacial history of part of northwestern Ontario," Geol. Assoc. Canada, *Proceedings*, Vol. 13, pp. 61–83.

1963: *Glacial features of the Canadian Lakehead area*, Ontario Dept. Lands and Forests, Research Branch, Contribution No. 63-64.

1965: "Glacial features of the Quetico-Nipigon area, Ontario, *Canadian Jour. Earth Sciences*, Vol. 2, No. 4, pp. 247–269.

Shale Deposits

Caley, J. F.

1940: *Paleozoic geology of the Toronto-Hamilton area, Ontario*, Geol. Surv. Canada, Memoir 224.

1941: *Paleozoic geology of the Brantford area, Ontario*, Geol. Surv. Canada, Memoir 226.

1943: *Paleozoic geology of the London area, Ontario*, Geol. Surv. Canada, Memoir 237.

1945: *Owen Sound, Ontario*, Geol. Surv. Canada, Paper 45-18.

Hume, G. S.

1925: *The Palaeozoic outlier of Lake Timiskaming, Ontario and Quebec*, Geol. Surv. Canada, Memoir 145.

LIBERTY, B. A.

1953: *Newmarket; Ontario and York Counties, Ontario*, Geol. Surv. Canada, Paper 53-2.

1953: *Alliston; Simcoe, York and Dufferin counties, Ontario*, Geol. Surv. Canada, Paper 53-9.

1953: *Oshawa; Ontario and Durham counties, Ontario*, Geol. Surv. Canada, Paper 53-18.

1953: *Scugog; Durham, Ontario and Victoria counties, Ontario*, Geol. Surv. Canada, Paper 53-19.

PARKS, W. A.

1925: *The stratigraphy and paleontology of Toronto and vicinity: part A, Stratigraphy and correlation of the Dundas formation*, Ontario Dept. Mines, Vol. 32, 1923, pt. 7, pp. 89–116.

SANFORD, B. V. and BRADY, W. B.

1955: *Paleozoic geology of the Windsor-Sarnia area, Ontario*, Geol. Surv. Canada, Memoir 278.

WILSON, A. E.

1946: *Geology of the Ottawa-St. Lawrence Lowland, Ontario and Quebec*, Geol. Surv. Canada, Memoir 241, (reprinted 1964).

A complete reference list of publications used in compiling this report is contained in the Bibliography. The maps contained in the text, illustrating the development of the glacial Great Lakes and of the outcrop belts for the principal shale formations, may be used as general guides to prospecting areas. For more detailed studies of specific areas, topographic maps are available at various scales; they may be helpful in locating deeply cut river banks or scarp exposures of clay or shale. They will also indicate broad flat river valleys that may contain flood-plain clays.

Stereoscopic examination of aerial photographs will help interpret land features in an area to be prospected. An air photo library is maintained by the Department of Lands and Forests at Downsview, Ontario, and photographs may be purchased from the same source.

The Geological Survey of Canada maintains a library at Ottawa of rock-cuttings from oil and gas well-drilling. A catalogue (Sanford, 1964) lists 4,628 wells drilled in Ontario (mostly southwestern Ontario) prior to June 1963 for which cuttings are available. Essential information as to location of the wells, drilled depths, and the oldest formations encountered is contained in the catalogue. Study of well-cuttings might be especially useful in the preliminary evaluation of shale deposits in drift-covered areas. The Ontario Department of Energy Resources and Management also maintains logs for oil and gas wells, and for all other drilling in Paleozoic rocks.

Information on the thickness and character of the drift in a given area may be obtained from water-well logs catalogued by the Ontario Water Resources Commission in Toronto. All persons drilling wells for water in Ontario are obliged to report depths and thicknesses of the various strata encountered, and this information is available for public examination.

CLAY COMPOSITION AND ITS RELATION TO BEDROCK

In southern Ontario there is a marked similarity between clay composition and the composition of the underlying bedrock, despite the fact that most of our clays have a glacial origin and the glaciers moved from north to south across the province. The distance of travel of the clay particles from their source rocks was, in most cases, not more than several miles in southern Ontario. In northern Ontario, however, the carrying power of the glaciers was apparently greater and clays derived largely from the Paleozoic lowlands around Hudson and James Bays are common on the Precambrian Shield several hundred miles to the south.

Limestones and dolomites predominate in the Paleozoic rocks of southern Ontario, hence limy, buff-burning clays are widespread. Red-burning clays will be found in areas underlain by non-calcareous bedrocks, such as the Muskoka and Haliburton areas where granite predominates, and the Hamilton-Aldershot area where the red sewer pipe clay had a shale origin. Because of surface weathering, involving the leaching and removal of lime, the upper few feet of otherwise buff-burning clay may also be red-burning. Marine clay in the Ottawa valley was largely derived from Precambrian non-calcareous rocks, and so is red-burning.

Testing of Clay and Shale

A considerable part of this report involves the testing of clay and shale samples taken from the pits and quarries of the active brick and tile producers. These samples were analysed chemically and mineralogically, and tested for their ceramic properties. All testwork was carried out by the Laboratory Branch of the Ontario Department of Mines using established methods which are outlined in the section that follows.

SAMPLING

Methods of sampling clay and shale deposits have been outlined by Phillips (1955). In the present survey, continuous vertical chip samples were taken from the working faces of shale quarries using a geological hammer and a cloth sample bag sewn to an aluminum fish-net frame. Vertical channel samples of clay were taken in the same way; the pointed end of a geological hammer was generally found more suitable than a trowel for sampling tough clays. Where uniformity permitted it, individual samples commonly represented vertical sections about 10 feet in length, but obvious changes in the strata were the main determinant for sample limits. In most cases samples weighed 3–5 pounds.

Quarry sections and pit faces were measured and described in detail. Sketches of the clay and shale sections are included in the descriptions of most properties.

CERAMIC TESTS

Ceramic testing of clay and shale is described in detail by Klinefelter and Hamlin (1957) and the reader is referred to this publication for detailed descriptions of most test methods. The testing programme used in the present survey is essentially that established by Brady (1957, pp. 71–72). Although ceramic testing is intended particularly for commercial evaluation of clay and shale, Dawson (1952) has pointed out its value also as an aid in correlating rock strata.

Examination of the Raw Clay or Shale. Physical descriptions of the raw materials were made in the field at the time of sampling. The presence of hard layers, stones, shells, concretions, and roots was recorded in the geological descriptions. Texture of the clays was reported as either sandy, silty, or smooth. Colour was noted in both the moist and dry states.

Sample Preparation. In the laboratory, samples were dried for several days at 185°F, then ground to pass a 16-mesh Tyler sieve. Analytical samples were split from the ground sample for chemical and mineralogical analyses.

Plasticity. Using 1600 to 1800 grams of the dry ground material, the sample was worked up to a plastic mass with tap water measured from a 500 millilitre graduated cylinder. Water of plasticity was calculated:

$$\%\ \text{Water of plasticity} = \frac{\begin{array}{c}\text{Weight of water}\\ \text{(grams)}\end{array}}{\begin{array}{c}\text{Weight of dry clay}\\ \text{(grams)}\end{array}} \times 100$$

The percent water of plasticity is a useful measure of the plasticity of clays. Clays are sometimes rated as follows:

Percent water	*Relative plasticity*
less than 20	low plasticity
20 to 35	moderate plasticity
more than 35	high plasticity

Hand-moulding of Briquettes. The moist clay mass was roughly shaped to approximately 8 by 4 by 2 inches, and divided by wire cutter into eight similar parts. These were individually pressed into a steel mould, lightly oiled to prevent sticking. After thorough tamping with the palm of the hand, excess clay was removed with the wire tool and the surface smoothed with a spatula. The finished briquette was discharged from the mould by its plunger-type base. Eight such briquettes, each 4 by 1½ inches, were made from each sample. While still soft, the sample number was impressed on their top surfaces along with a characterizing letter for each briquette. Two control marks were cut 3 inches apart for subsequent shrinkage calculations. Five standard-sized cones were also cut from the clay mass.

Drying Characteristics. One briquette was weighed immediately after forming, and again after drying, to determine its moisture content as a check on the water of plasticity determination. Another briquette was exposed to a temperature of 185°F for a period of 20 minutes to determine its resistance to warping and cracking under conditions of rapid drying. The remaining briquettes were air dried for 24 hours, then oven dried for 24 hours at 185°F.

All briquettes were allowed to cool, and their dry weights were obtained immediately. The percent lineal drying shrinkage was determined from the shortening of the interval between the two control marks. All briquettes were examined for signs of cracking or warping.

Firing Characteristics. Briquettes were fired in a globar-type furnace designed both for ceramic testwork and conventional assay work. Inside measurements of the heating chamber are 13 inches high, 16 inches wide, and 23 inches deep. Heating is accomplished by means of ten silicon carbide elements located in the floor and walls. The furnace is rated at 25 K.V.A. and is designed for continuous operation at 2600°F with maximum element temperature of 2867°F. Walls and roof are lined with 9 inches of firebrick backed by 4 inches of monoblock insulation.

The briquette used in the rapid drying test, and one other, were retained as spares; the other six briquettes were fired in pairs to three peak cones: cone 010, cone 06 and cone 03. Average temperatures measured by optical pyrometer for eight furnace runs to each peak cone were 1660°F, 1840°F and 1980°F respectively. Eighty briquettes, representing forty samples, could be fired at a time. Briquettes were arranged on two shelves so that duplicate briquettes were not on the same shelf. In some cases briquettes on the lower shelf exhibited slightly higher temperature characteristics, than those on the upper shelf. Shrinkage, absorption, and specific gravity measurements are reported as the average of the two briquettes.

Heating of the furnace is controlled by a Honeywell electronic circular chart programme controller and recorder, with integral cam-driven index and motor-driven plastic cam. Heating rate was programmed to rise from room temperature to about 1500°F in 16–17 hours, then more rapidly to the finishing temperature. Finishing temperature was determined both by standard cones and readings with the optical pyrometer on the firebrick lining at both ends of the furnace. The furnace was turned off just below the end point, to allow for over-ride, and was permitted to cool with slight draught for about 24 hours. There was no "soaking" at the peak temperature. Briquettes were removed from the furnace at a temperature of 500–600°F, and were weighed when cool.

Linear Fired Shrinkage. The interval between the control marks was measured, and the percentage shrinkage or expansion due to firing was calculated.

Hardness. Hardness of the fired briquettes was measured relative to a hardened steel needle, having a value of 6½ in the Mohs scale of hardness. Briquettes were recorded as "very hard" if they could not be scratched by the needle, "hard" if they had about the same hardness as the needle, "almost hard" if they could just be scratched, and "moderately hard," "rather soft," or "soft," depending on the ease with which they could be scratched.

Colour and General Appearance. The colour of the fired briquette was recorded, usually with suitable modification as to "dark," "medium," or "pale." Notes were also made as to the general appearance of the fired briquettes—deformation (warping) or cracking, smooth or blistered surface, presence of scum, overfired condition etc.

Absorption by 24-hour Cold Water Submersion. Absorption was determined by a similar method to that used for full-size brick, as outlined in specification A 82.2 of the Canadian Standards Association. The dried, weighed, briquettes were submerged on edge in a pan of tap water at room temperature for 24 hours, after which the excess surface moisture was removed with a damp sponge and the briquettes re-weighed.

$$\text{Percent absorption} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$$

Absorption by 5-hour Boiling Test. Absorption was also determined by the 5-hour boiling test (CSA specification A 82.2). The same briquettes that had been saturated in the 24-hour absorption test were returned to the pan, the water was heated rapidly to boiling, and boiled continuously for 5 hours. After the water had cooled to room temperature through natural loss of heat the briquettes were lightly sponged as before and weighed. The percentage absorption was based on the dry weight as before.

Saturation Coefficient. One of the most useful calculations in estimating the durability of brick is that which relates the two previous absorption determinations. According to specification A 82.1 of the Canadian Standards Association:

> saturation coefficient, when used in conjunction with compressive strength and total absorption by 5-hour boiling, has been found to provide a means of predicting the resistance of most types of brick to freezing-and-thawing tests with greater accuracy than any other method developed to date.

The saturation coefficient is the ratio of the absorption by 24-hour submersion in cold water to the absorption after 5-hour submersion is boiling water, and is defined generally as the ratio of easily filled to total fillable pore space. The theory of the saturation coefficient is that if only a part of the total pore space is occupied by water, there is room for expansion on freezing into the remaining pore space without disruption of the material. The data indicate that if the easily fillable pore space, that is, the maximum water that might be absorbed by a brick in a wall subjected to excessive moisture, does not exceed 80 percent of the total space, the remaining space will relieve the pressure due to expansion on freezing.

$$\text{Saturation coefficient} = \frac{\text{Absorption by 24-hour submersion test}}{\text{Absorption by 5-hour boiling test}}$$

Although the theory of saturation coefficient is applicable to most types of brick there may be certain exceptions.

> If the average compressive strength is greater than 8,000 psi or the average water absorption is less than 8.0 percent after 24-hour submersion in cold water, the requirement for saturation coefficient shall be waived. (CSA specification A 82.1–1954, clause 5).
>
> The relationship also does not appear to hold for some brick of very high absorption (exceeding the maximum permitted in this Specification) and the acceptance of these products should be in accordance with clause 6 [CSA specification A 82.1–1954], which provides for special measures based upon actual freezing-and-thawing tests of the particular product.

Neither freezing-and-thawing nor compressive strength tests are considered significant on hand-moulded briquettes. Durability and strength are so closely related to the forming method that these tests are meaningful only on products formed by actual commercial processes.

Bulk Specific Gravity. Bulk specific gravity is the specific gravity of the fired briquette, pore spaces included. It is seldom required in specifications for heavy clay products.

Bulk specific gravity is easily determined on the saturated briquettes, and so is included in the ceramic tests. It supplements the other physical tests in indicating the degree of vitrification of the fired briquettes. Briquettes saturated by the 5-hour boiling absorption test are weighed suspended in water. The suspended weight is subtracted from the weight of the saturated briquette and the difference is divided into the dry fired weight.

$$\text{Bulk specific gravity} = \frac{\text{Dry fired weight (grams)}}{\text{Saturated weight (grams)} - \text{Suspended weight (grams)}}$$

Pyrometric Cone Equivalent. Five standard-sized cones were cut or moulded from the plastic clay mass. Standard cones have an equilateral triangular base 1.5 cm. on a side; they are 5 cm. high and one vertical edge of the cone is at right angles to the base. The cones were dried for 24 hours at 185°F and kept in a desiccator until used.

A small pot furnace designed specifically for P.C.E. determinations by the Denver Fire Clay Company was used. Heating is accomplished by radial jets; the furnace is gas-fired using forced air provided by an auxiliary fan.

The test cone was placed upright on a circular plaque along with a range of standard cones; the cones were equally spaced around the periphery of the plaque. The plaques used were about 2¼ inches in diameter and held 5 cones. The test cone was constantly observed through a port in the top of the furnace. The heating rate was maintained as nearly as possible at the prescribed 270°F per hour, necessitating close control of air and gas. When bending commenced in the test sample, the number of the standard cone that most closely resembled the test cone was taken as the P.C.E. of the test material. The end point was taken when the tip of the test cone just touched the plaque.

CHEMICAL ANALYSES

Partial chemical analyses were performed on all clay and shale samples. In many cases complete analyses were made on weighted composites consisting of all the samples taken from any one pit or quarry.

Partial analyses included determinations of lime (CaO), iron (Fe_2O_3), soluble salts, and loss on ignition. Lime and iron determinations were made by emission spectrography; soluble salts and loss on ignition were determined by conventional chemical analysis.

These determinations were selected to point out essential variations in clay and shale strata; 146 samples were so treated. Partial analyses provide information on the probable colour of the fired product, the propensity towards the formation of scum and efflorescence, and the proportion of combustible materials, which as a result of gas evolution, may influence the heating rate in the kiln. The intention was to provide a basis for increased quality control in the pit or quarry, such that, even though the samples are closely spaced, they represent mineable units that might be selected or rejected in quarrying depending on whether or not they contributed to the desired end result.

Complete analyses included determinations of silica (SiO_2), alumina (Al_2O_3), iron (Fe_2O_3), lime (CaO), magnesia (MgO), soda (Na_2O), potash (K_2O), titania (TiO_2), carbon dioxide (CO_2), combined water (H_2O+), moisture (H_2O-), sulphur trioxide (SO_3), and loss on ignition. The determinations were made by a combination of chemical and spectrographic methods; 41 samples were analysed.

Carbon dioxide was determined by a chemical volumetric method. Using the Dreimanis (1961) method, a gasometric method using Chittick apparatus, calcite and dolomite were also determined. In practically all cases the results compared so favourably with calcite and dolomite determinations by x-ray diffraction that only the latter are reproduced in the report (see Mineral Analyses).

Loss on ignition was done as a confirmation of the sum of carbon dioxide and total water.

All analytical work was performed by the Laboratory Branch, Ontario Department of Mines.

MINERAL ANALYSES

The mineral compositions of all samples, including composite samples, were obtained by x-ray diffraction analysis as outlined in the notes that follow. Brady and Dean (1965) and Sadler (1962) have recently published mineralogical data on samples from many clay and shale pits in Ontario. In general, their studies of the clay minerals have been more intensive than those contained herein, and the reader is referred to their reports for further information.

Notes on the Mineralogical Analysis of Ontario Shales and Clays

by R. K. Laakso, X-ray Spectrographer, Laboratory Branch, Ontario Department of Mines

The following notes include the methods used in the mineral analyses, observations from the analyses, and discussion of the results and methods.

METHODS

For purpose of mineralogical analysis the shales and clays have been treated as two fractions; (1) clay minerals, and (2) non-clay minerals. The clay mineralogy is qualitative, but the non-clay mineralogy is quantitative.

Clay mineral portion

(a) Approximately one gram of coarsely crushed sample was placed in a 400 ml ceramic dish and mixed with approximately 50 ml of distilled water. A small amount of NaOH was added until the liquid was slightly basic to deflocculate the clay. After allowing to stand for a few minutes, part of the clay mineral-bearing liquid was run onto a glass slide and allowed to dry overnight.

(b) Some samples, high in calcite and/or dolomite, were pretreated with weak HCl to dissolve the carbonates and then washed several times. The insoluble residue was treated as in (a).

(c) The slides were run on the diffractometer for clay minerals.

(d) Those samples which exhibited a fair 14Å peak were tested for expanding-layer clay minerals by first heating the slide to just over 200°C (infra-red lamp) and observing on the diffractometer tracing if a shift of the 14Å peak to a lower spacing had resulted. If the 14Å peak was strong, another slide was prepared and tested for montmorillonoids by spraying the air-dried slide with glycerol. The slide was re-run to observe any shift of the 14Å peak to higher *d* spacings.

Discussion. This appears to be a crude method but it has been found that strong clay mineral reflections are possible with this small amount of handling and chemical preparation. Harward and Theisen (1962) found that "clay mineral identification by x-ray diffraction may be arbitrary and empirical" and that many of the minerals found can be due to sample preparation, thus justifying as little handling and chemical work as possible. Our methods have been conditioned by the need for rapid and simple preparation, because of the great number of samples, and by the objective of identification of the clay minerals actually present in the sample.

Non-clay portion

The minerals of the non-clay portion (quartz, calcite, dolomite, feldspars, amphibole) are not platy in structure and have less of a tendency to exhibit preferred orientation. Therefore an attempt was made to analyse for these minerals quantitatively.

Absorption of x-rays in a sample is perhaps the most important single interfering factor affecting the

TABLE 9

	Number of runs	Mean determined value %	Standard deviation	Relative deviation %	95% Probability Range %
Quartz	33	37.3	2.5	7	32.3–42.3
Calcite	16	6.1	0.9	15	4.3–7.9
Dolomite	16	7.5	1.3	17	4.9–10.1
Soda-lime feldspar	16	5.8	1.1	18	3.6–8.0
Potash feldspar	16	1.4	0.45	32	0.5–2.3

intensity of diffraction peaks. Absorption by varying matrixes can be allowed for by applying formulae developed from the basic theory of absorption in powder mixtures [Alexander and Klug (1948), Leroux, Lennox, Kay, (1953)].

In our work the samples and standards were milled to minus 200 mesh in a ceramic vial mill. This material was then carefully packed into the diffractometer holder and run several times slowly (4 min/deg) over the peak sought. The average area (width at half height times the height) found under the curve was taken as the intensity factor for the mineral sought. The mass absorption coefficient for the sample was estimated using x-ray fluorescence. A curve was plotted of the intensity of a tungsten peak (wave length 1.476 Å) against the known mass absorption coefficient for copper radiation (wave length 1.542 Å) in standards. The mass absorption coefficient for unknown samples was then obtained from this graph after measuring their tungsten peak intensity. (In this method it is assumed that the mass absorption coefficient for tungsten will be relatively the same as for copper in the samples being analysed. This assumption should be reasonably true for geological samples such as the clays and shales analysed here.)

The mass absorption coefficient for the minerals being analysed was calculated from absorption tables.

The intensity for 100 percent of minerals and a correction factor applied by Leroux, Lennox, and Kay (1953) were lumped together as a *K* factor. The *K* factor for a given mineral run was obtainable because mineral percent, mineral areal intensity, mineral and sample mass absorption coefficients were obtained or were known in the standards.

Thus the mineral percents can be calculated for unknowns from the data obtained as suggested above, using the absorption formula in Leroux, Lennox, and Kay (1953).

PRECISION

The over-all precision is determined by instrumentation, sample properties, sampling and preparation. A clay was sampled, packed, and run a total of 33 times for quartz and 16 times for calcite, dolomite, soda-lime feldspar, and potash feldspar over a period of several months and the data in Table 9 were obtained.

ACCURACY

X-ray results for quartz were checked against several chemically determined results on clay standards and the agreement was reasonable. X-ray results for calcite and dolomite compared favourably with results determined by the Dreimanis-Chittick Method (Dreimanis, 1961).

DIFFERENTIAL THERMAL ANALYSES

The differential thermal analysis (D.T.A.) of a clay or shale is another way of obtaining semi-quantitative information on its mineral content. The method also gives the temperature ranges for exothermic and endothermic reactions, data that may be useful in determining the firing schedule in the plant.

Differential thermal analyses are usually recorded graphically, so that a continuous curve is plotted representing the difference in temperature between an inert reference material, whose temperature changes uniformly with that of the furnace, and the test sample. The temperature of the test sample deviates from that of the reference material when an endothermic or exothermic reaction takes place in it. A sensitive thermocouple records the difference. The method and apparatus are described by Collins and Swan (1954) and Brady (1957).

Clay and shale samples collected during the present survey were not tested by D.T.A., but Brady and Dean (1965) and Sadler (1962) give D.T.A. curves for other samples taken from many of the same pits and quarries.

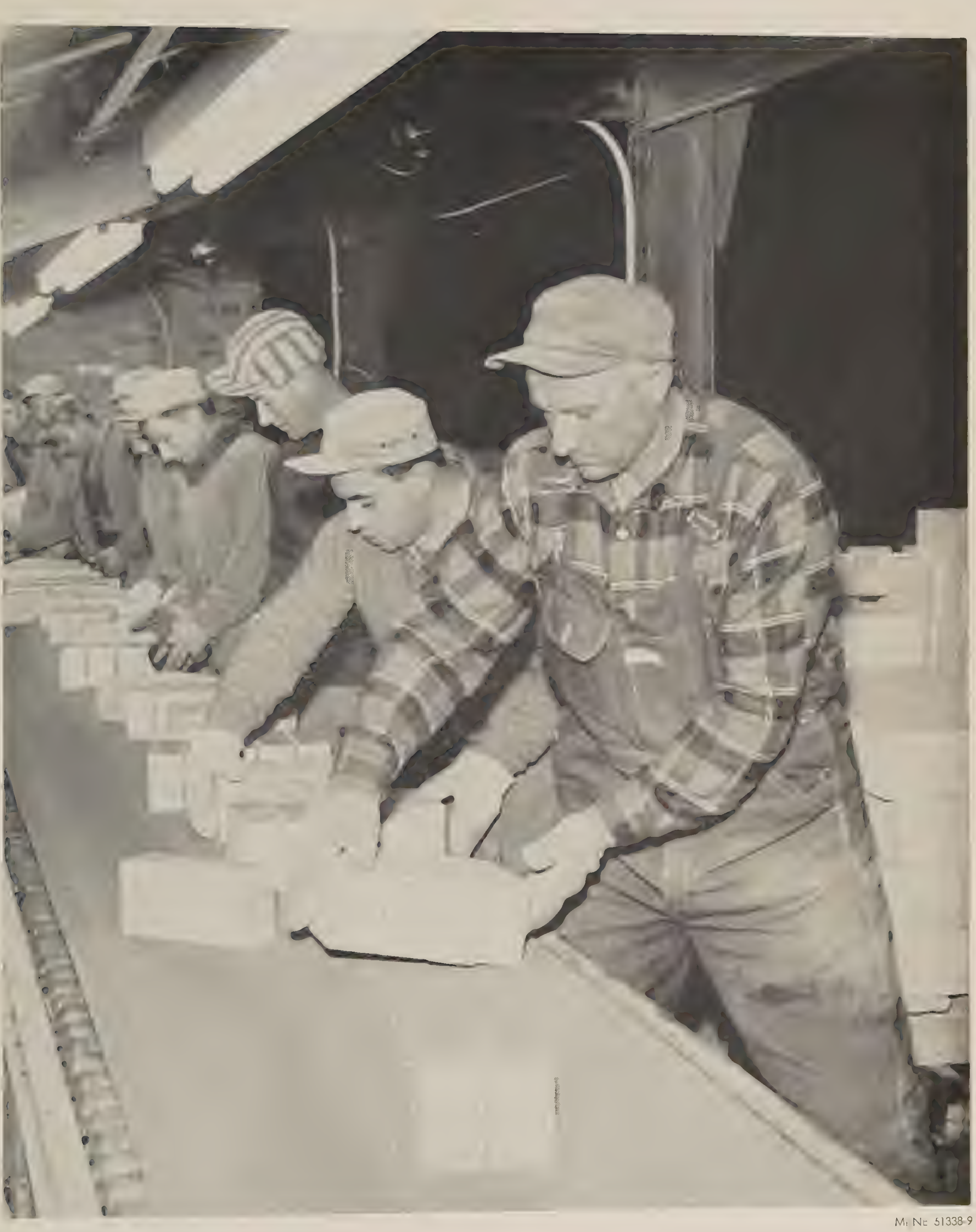


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Photo 13–Hacking brick from the production conveyor into units for drying. (Photo by Gilbert A. Milne and Co. Ltd., Toronto; courtesy Canadian Structural Clay Association, Willowdale.)

DILATOMETRY

Brady, Bell, and Zemgals (1965) describe a method for measuring the thermal expansion and shrinkage of unfired and fired clay or shale samples. Most raw clays and shales expand gradually on heating, but show rapid shrinkage once vitrification begins. Brady and Dean (1965) show the results for nine selected samples of Ontario clays and shales. Bell (1965) investigates the influence of lime on the thermal expansion of clays and shales.

THERMOGRAVIMETRIC DETERMINATIONS

A continuous record showing loss in weight of clay and shale samples during heating can be obtained with a high temperature thermobalance. Brady and Dean (1965) outline the method and give the results of testing of the nine Ontario samples used in the dilatometry studies.

Producers of Heavy Clay Products in Ontario

The results of a survey of brick, tile, and sewer pipe plants made in 1961 are contained in the following chapters. Practically all the plants were revisited in 1965 so that changes in production facilities to that time have been incorporated in the plant descriptions. No further sampling of raw materials was carried out in 1965, but in most cases changes in this regard were few, so that the 1961 samples are applicable.

In describing the various plants, the author used a 6-foot steel tape to obtain the approximate sizes of various pieces of plant machinery; precise dimensions and capacities should be obtained from equipment suppliers. Renovations to equipment, particularly in the older plants, in some cases have resulted in considerable change from the original specifications.

Rolls-type crushers are particularly suited to the milling of clay and shale. They are effective in breaking up dry clay lumps and small stones; stones too large for the nip of the rolls can be removed manually or by means of a mechanical kick-out device. Dimensions of the rolls given in the following plant descriptions refer to their diameters and their lengths (face lengths), in that order; when only one dimension is given it refers to face length unless otherwise specified.

All capacities (for plants, equipment, dryers, kilns, etc.) given in the plant descriptions refer either to standard Ontario-size brick (8⅜ × 4 × 2⅜ inches) or 4-inch diameter (12 inches in length) drain tile, unless otherwise stated. Vacuum pressures in de-airing auger extrusion machines are measured in inches of mercury.

In tabulating the ceramic test results, the peak firing points are given both in terms of cones and the average peak temperatures of a series of furnace runs measured by optical pyrometer. These temperatures differ somewhat from the published cone equivalents because of the different heating rates.

Saturation coefficients are not given in the ceramic test results because they are essentially product specifications applicable mainly to brick. The sampling of individual clay or shale layers, the preparation of these samples without blending or additives, and the hand-moulding and laboratory firing procedures used in the testwork, are sufficiently different from commercial plant procedures that the reporting of saturation coefficients would have questionable significance. If desired, the saturation coefficient can be easily calculated from the absorption data reported for each sample.

Part II Dundas Shale

Shale of the Dundas Formation is the principal raw material for five brick plants in the Toronto area. The shale outcrops in a belt 20 miles wide at Lake Ontario, extending between Cooksville and the east side of Toronto, and continues north with diminishing width through Woodbridge, Bolton, and Meaford, passing under the waters of Georgian Bay along the west side of Nottawasaga Bay, and outcropping again along the east side of Manitoulin Island. A small outcrop also occurs east of Ottawa in Carleton and Russell counties. In the Toronto area the formation dips south or southwest at 20 feet per mile. It lies beneath the grey and red shales of the Meaford and Queenston Formations respectively. Exposures are few and practically confined to the Toronto area where they are seen on the lower reaches of the Humber and Credit rivers and Mimico and Etobicoke creeks. There are no quarries more than 5 miles north of Lake Ontario. Map 2131 (see back pocket) shows the outcrop belt for the Meaford, Dundas, and Blue Mountain shales, undivided because of their lithological similarities and the scarcity of exposures.

DUNDAS FORMATION

The Dundas shale is of Upper Ordovician age. It was formerly referred to as Lorraine shale (Montgomery 1930, p. 21) because of its similarity to grey shales at Lorraine, New York, but the term Dundas is now preferred in Ontario as a formational name for shales of Lorraine age. The Dundas Formation is underlain by the Blue Mountain and Collingwood shales, formerly referred to, together, as the Billings Formation. Dundas shales are overlain by the Meaford Formation. Both the underlying Blue Mountain and the overlying Meaford shales are similar to the Dundas shale, and the contacts are difficult to place. The lower contact is marked where hard limestone interbeds become scarce (Winder 1961, p. 16), the Blue Mountain Formation consisting almost entirely of soft blue-grey shale. The upper contact is marked by a zone barren of fossils (Dyer 1925, p. 120) and by an increase in the number of hard limy and sandy layers in the Meaford Formation (Caley 1940, p. 16). The combined Meaford-Dundas-Blue Mountain shales are about 640 feet thick at Toronto, of which about 400 feet are true Dundas shales (Caley 1940, p. 17). The formations thin towards the west (Sanford 1961, p. 14). Seventy-three feet of Dundas shale is exposed in the quarry of the Toronto Brick Company Limited in east-central Toronto.

LITHOLOGY

The soft grey, Dundas shale has a platy lamination on a thin- to medium-bedding structure; it breaks into thin tabular fragments with conchoidal fracture. Hard layers interbedded with the shale comprise 10–20 percent of a typical Dundas section. The hard layers can usually be recognized as either limy or sandy, but all variations in composition from shale to limestone to sandstone occur. The more limy layers tend to be brown-grey in colour, coarser-grained, often fossiliferous, and have an uneven fracture. The sandier ones are blue-grey, finer-grained, more uniform in extent and thickness, and break with a sharp, even, fracture. Hard layers seldom exceed 6 inches in thickness and are distinctly lenticular, any one layer rarely being traceable laterally for more than a few hundred feet. They usually grade downwards into normal shale but have sharp upper contacts.

SUBDIVISION OF THE DUNDAS FORMATION

Fossils are common throughout most of the Dundas Formation. The appearance, relative abundance, and disappearance of various species makes it possible to divide the formation into various units or members. W. A. Parks (1925, pp. 99–116) has divided the Dundas Formation into four members, designated from bottom to top as the Rosedale, Danforth, Humber, and Credit. The members are not particularly distinctive in lithology and composition.

Rosedale Member. The lowest exposure of Dundas shale is to be seen in the Don Valley quarry of Toronto Brick Company Limited. The bottom 18 feet of the shale section belongs to the Rosedale Member which continues an unknown depth below the quarry floor. The member is distinguished by the number and variety of pelecypods belonging to the Whitella genus. Lithologically the Rosedale Member is a thin- to medium-bedded, medium blue-grey or

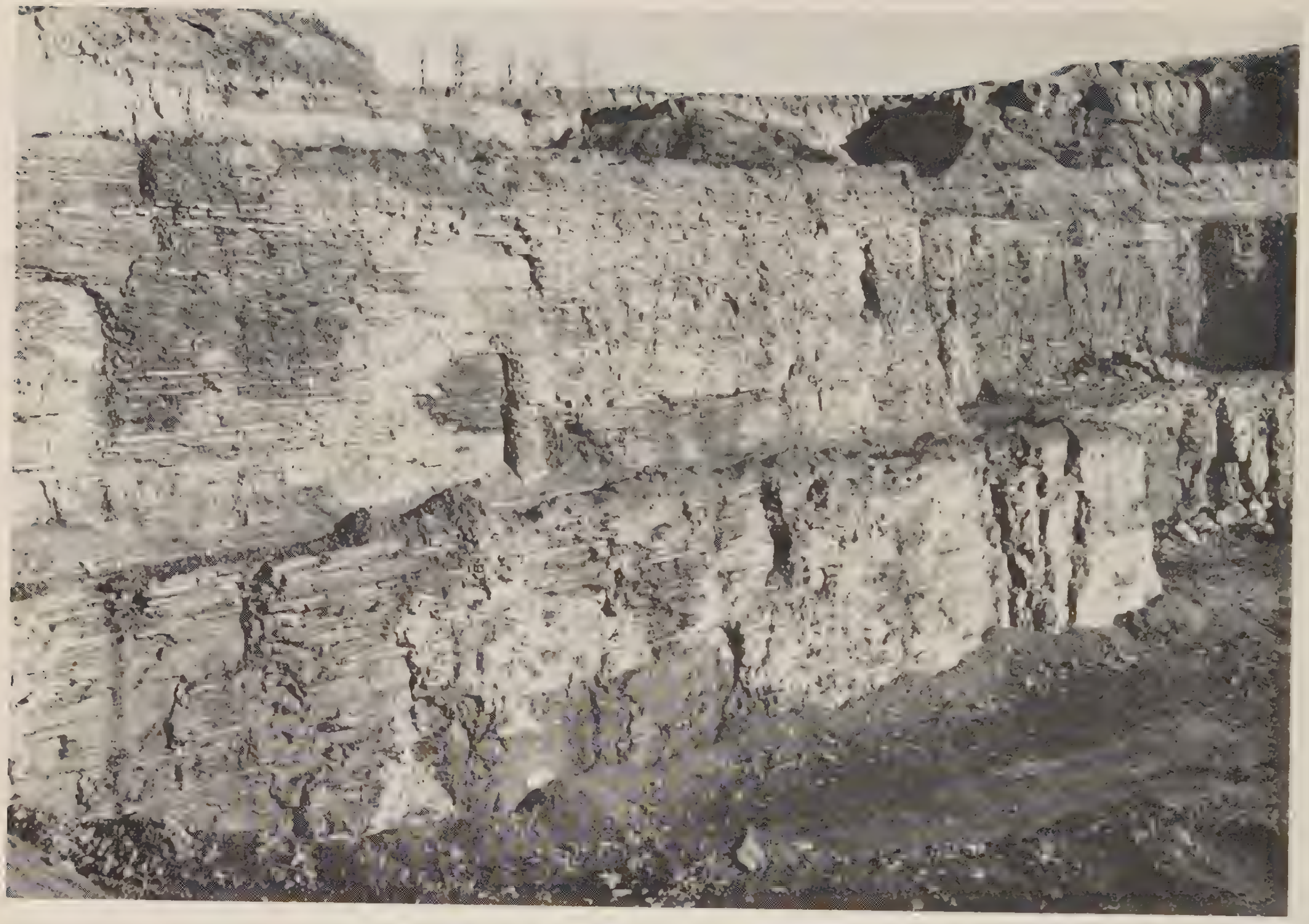

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Photo 14–Dundas shale in the Don Valley quarry of Toronto Brick Company Limited.

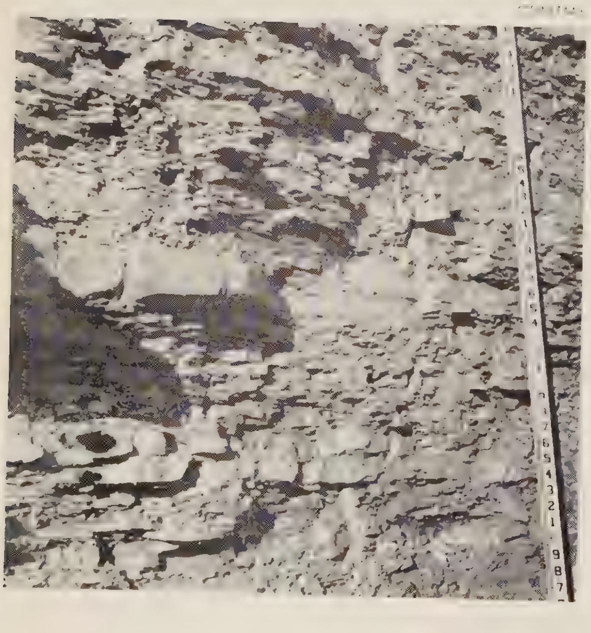


Photo 15–Close-up of Dundas shale showing platy lamination and hard layers. The scale is marked in tenths of a foot.

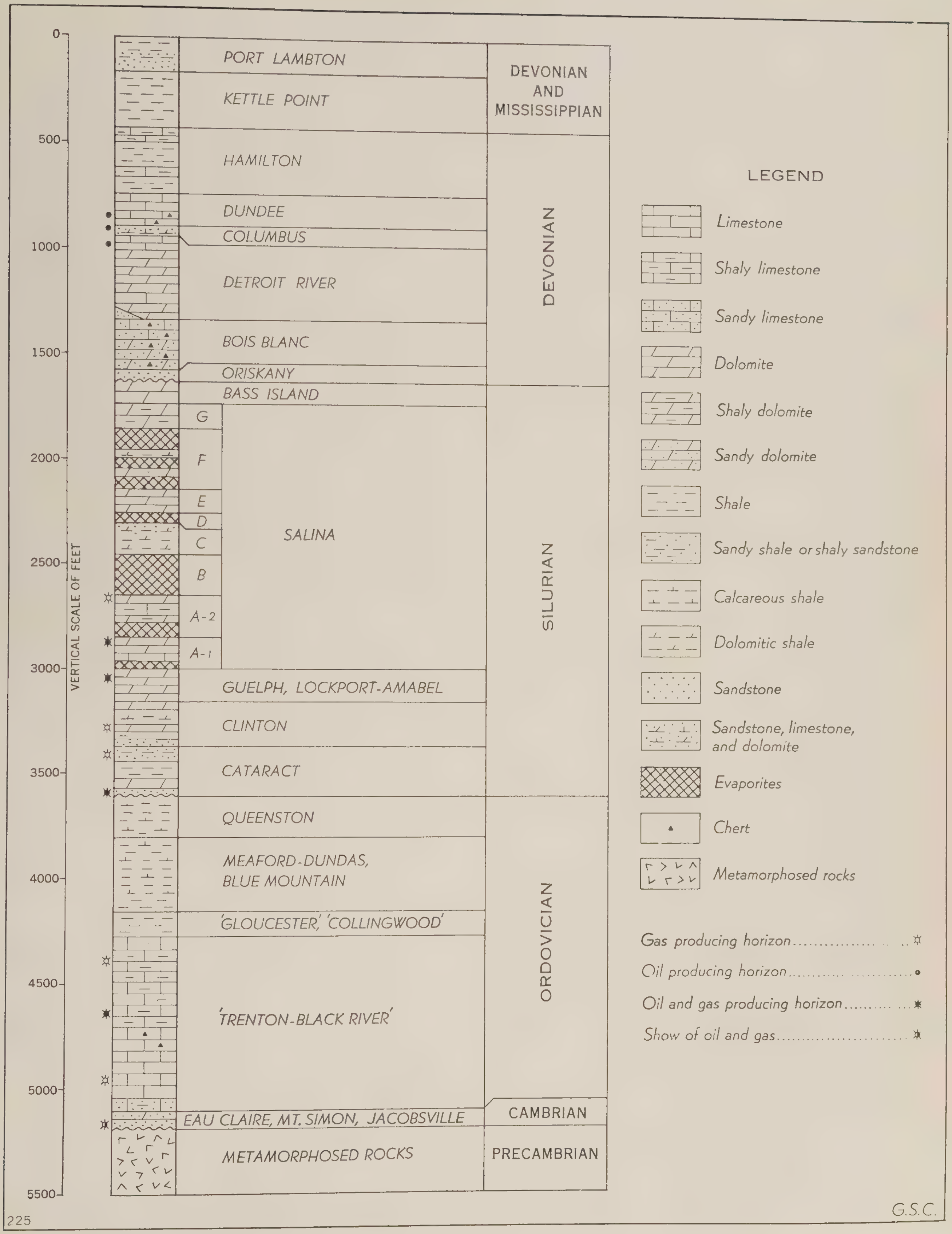

VERTICAL SCALE OF FEET
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
PORT LAMBTON
KETTLE POINT
DEVONIAN AND MISSISSIPPIAN
HAMILTON
DUNDEE
COLUMBUS
DETROIT RIVER
DEVONIAN
BOIS BLANC
ORISKANY
BASS ISLAND
G
F
E
D
C
B
A-2
A-1
SALINA
SILURIAN
GUELPH, LOCKPORT-AMABEL
CLINTON
CATARACT
QUEENSTON
MEAFORD-DUNDAS, BLUE MOUNTAIN
'GLOUCESTER,' 'COLLINGWOOD'
'TRENTON-BLACK RIVER'
ORDOVICIAN
EAU CLAIRE, MT. SIMON, JACOBSVILLE
CAMBRIAN
METAMORPHOSED ROCKS
PRECAMBRIAN
LEGEND
Limestone
Shaly limestone
Sandy limestone
Dolomite
Shaly dolomite
Sandy dolomite
Shale
Sandy shale or shaly sandstone
Calcareous shale
Dolomitic shale
Sandstone
Sandstone, limestone, and dolomite
Evaporites
Chert
Metamorphosed rocks
Gas producing horizon
Oil producing horizon
Oil and gas producing horizon
Show of oil and gas
225
G.S.C.

Figure 2–Generalized geological columnar section for southwestern Ontario.

green-grey, soft platy shale containing a few thin discontinuous hard limy layers. The upper limit of the Rosedale Member is marked by a sharp decrease in Whitella fossils and by a general increase in the number and thickness of hard layers.

M. A. Fritz (1926, p. 84) recognizes 25 feet of strata belonging to the Rosedale Member at Meaford on Georgian Bay.

Danforth Member. Above the Rosedale Member in the Don Valley quarry of Toronto Brick Company Limited there is 55 feet of Dundas shale belonging to the Danforth Member. This member is sharply distinguished on a faunal basis by several species of the Bryozoa genus Hallopora, and great numbers of Plectambonites sericeus (Parks 1925, p. 108). Lithologically the member consists of thin- to medium-bedded, green-grey, soft platy shale, containing a moderate number of hard discontinuous limy and sandy layers. The upper limit of the Danforth Member is not exposed.

M. A. Fritz (1926, p. 85) recognizes 68 feet of strata belonging to the Danforth Member near Meaford on Georgian Bay.

Humber Member. The Humber Member is the thickest unit of the Dundas Formation, and is exposed west of Toronto in the quarries of Booth Brick Company Limited, the Ontario Reformatory, and Domtar Construction Materials Limited. Exposures along the Humber River between Lake Ontario and Weston indicate a thickness for the member of at least 282 feet (Caley 1940, p. 18). The member is distinguished on faunal grounds, not by one or two distinctive fossils, but by the disappearance, occurrence, or relative development of a considerable variety of fossils indicative of a significant time change. Lithologically the Humber Member consists of thin- to medium-bedded, soft, platy, dark grey shale in which thin lenticular interbeds of hard sandy and limy rock are relatively common. According to Parks (1925, p. 109) the proportion of hard sandy layers and fossiliferous lenses is greater in the Humber Member than in the underlying Danforth and Rosedale members. However, the upper third of the Humber Member is practically devoid of fossils, and the top of this barren zone is taken as the upper limit of the member (Dyer 1925, p. 119).

M. A. Fritz (1926, p. 86) recognizes 91 feet of Humber strata near Meaford on Georgian Bay. The Humber Member also outcrops along the east side of Manitoulin Island.

Credit (Christie) Member. The uppermost member of the Dundas Formation is known as the Christie Member near Meaford (Fritz, 1926, p. 89). It is about 50 feet thick near the mouth of the Credit River, and 67 feet thick at Meaford. Layers of fossiliferous limestone are common in a 20-foot section at the base of the Credit Member, and large trilobite fossils (Isotelus maximus) are particularly abundant. At Meaford, on Georgian Bay, the fossil record found in the hard limy bands is sufficiently different to justify a local name (Christie) even though the strata occupy the same relative position as at Toronto (Fritz 1926, p. 89). The Christie Member also outcrops along the east side of Manitoulin Island. In the Toronto area a 30-foot zone of barren shale above the limy zone marks the upper limit of the member. A distinct faunal assemblage associated with the increased occurrence of hard limy layers is diagnostic for the overlying Meaford Formation (Dyer 1925, p. 120).

CERAMIC PROPERTIES

As a raw material for brick and tile manufacture Dundas shale has just sufficient workability for modern extrusion equipment. It burns red, and has a rather short firing range. Sandy hard layers reduce the plasticity of the shale and limy ones weaken the burned red colour, and it is therefore desirable to remove as many fragments as possible from the plant feed.

TABLE 10 Ceramic Properties of Dundas Shale

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	2.3
Pyrometric cone equivalent	5

	Cones		
	010	06	03
	(1660°F)	(1840°F)	(1980°F)
Lineal firing shrinkage (%)	0.1	0.6	2.4
24-hour cold water absorption (%)	13.1	11.7	4.3
5-hour boil absorption (%)	14.6	13.8	6.8

The average properties of unweathered Dundas shale from four active brick quarries in the Toronto area are outlined in Table 10.

CHEMICAL COMPOSITION

There is little variation in the chemical composition of the Dundas shale. In 16 vertical channel samples, taken from four active brick quarries, lime (CaO) varies from 3.03 to 6.92 percent, and iron (Fe_2O_3) varies from 5.75 to 6.97 percent. Lime is mostly associated with the hard layers.

In the analyses that follow (Table 11), the compositions of the hard layers (Parks, 1925, p. 97) are compared with the average analysis of the pure shale from seven Ontario locations (Keele, 1924, p. 19). The average analysis for composites of channel samples of the shale and hard layers in four brick quarries sampled by the writer (analysis by Laboratory Branch, Ontario Department of Mines) is shown in the first column.

TABLE 11 Chemical Composition of Dundas Shale

	Average Analysis	Pure Dundas Shale	Limy Layer	Sandy Layer
	(percent)	*(percent)*	*(percent)*	*(percent)*
SiO_2	55.66	58.74	34.7	63.6
Al_2O_3	15.3	17.90	9.0	15.0
Fe_2O_3	6.60	7.50		
CaO	4.63	2.37	30.3	7.3
MgO	2.82	2.84	trace	trace
Na_2O	0.93	4.03		
K_2O	3.51			
TiO_2	0.89			
CO_2	4.06	8.26	24.7	9.3
H_2O+	3.38			
H_2O-	1.00			
SO_3	0.78			
TOTALS	99.6	101.64	98.7	95.2

MINERAL COMPOSITION

X-ray diffraction studies of 15 channel samples from four active quarries indicate that the average content of clay minerals in Dundas shale is 60 percent. Illite is the most abundant clay mineral and chlorite is present in moderate amount. None of the expanding type of clay minerals was detected. The average composition of the non-clay fraction was determined by the Laboratory Branch, Ontario Department of Mines, as shown in Table 12.

TABLE 12 Non-clay Minerals in Dundas Shale

	Average of 15 samples	Range
	(percent)	*(percent)*
Quartz	28	23–35
Calcite	7	3–17
Dolomite	1	0–4
Soda-lime feldspar	3	<0.5–8
Potash feldspar	0.5	0–3

Gypsum has not been observed in discreet units in the Dundas shale, but a white efflorescence is usually common on weathered exposures of the shale. Pyrite (FeS_2) occurs in trace amounts, particularly in hard sandy layers. Common practice requires the addition of barium carbonate to the plant feed to control scumming tendencies of the sulphurous compounds.

Producers Using Dundas Shale

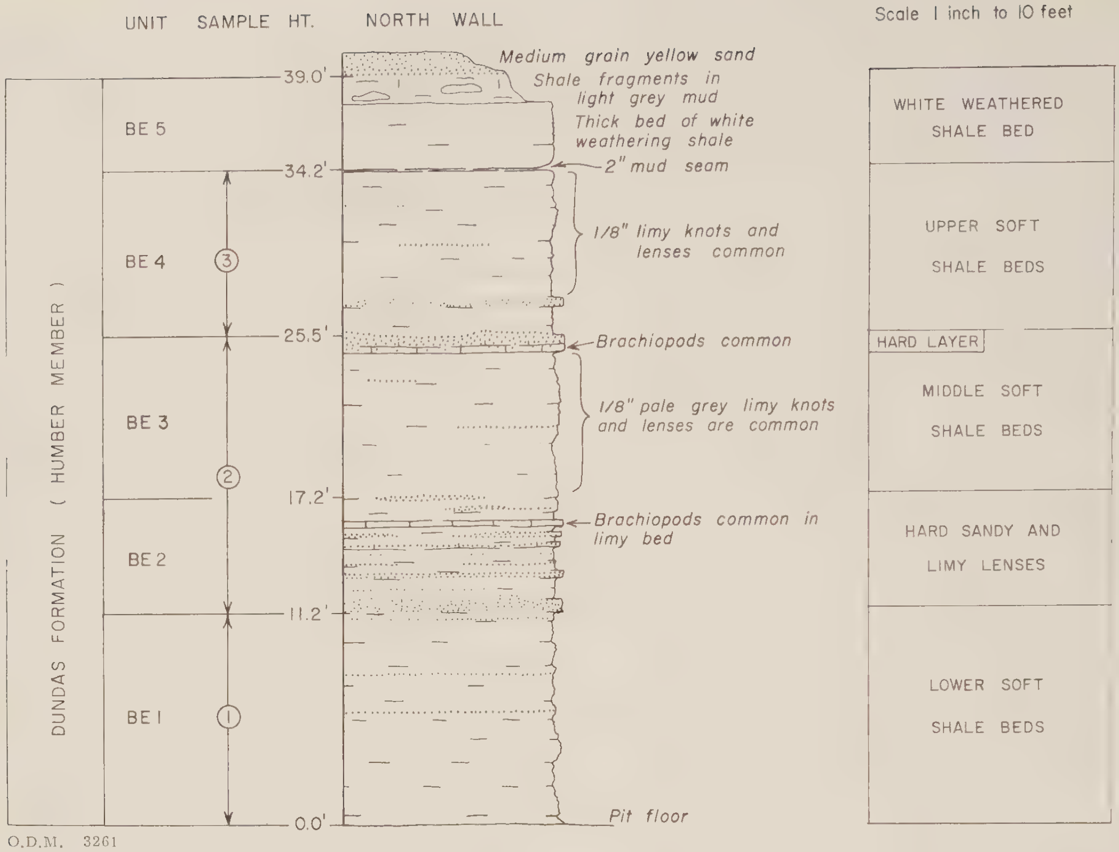
BOOTH BRICK LIMITED

The late F. W. Booth was president of two brick plants in the Toronto area. His grandfather, Wm. Booth, started making brick in North Toronto in 1887, and his father, G. W. Booth, designed and built the first successful tunnel kiln in the province in 1917. W. D. Booth, the fourth generation in the family's brick business, is manager of the two plants. The North York plant was built in 1929 and is located on Edgar Avenue a short distance west of the junction of highways nos. 400 and 401. The original Etobicoke plant was built in 1912, but it has been largely rebuilt following a fire in 1960. Head office for the company is located at the Etobicoke plant, 320 Horner Avenue, Toronto 14. Early descriptions of the two plants are given by Montgomery (1930, pp. 167–168).

Etobicoke Plant

The capacity of the rebuilt Etobicoke plant is rated at 20 million brick annually. Brick are produced in a full range of colours and textures.

The Dundas shale is drilled by 4-inch cable-tool to depths of 52 feet. Normal spacing for the single row of holes is 8 feet, drilled 10 feet back from the face. Some 1,500 tons are blasted at one time using 40 percent dynamite. The shale is loaded by a 1-yard Northwest diesel shovel and trucked about 800 feet to the plant by a Mack quarry truck. A 42-inch apron feeder conveys shale from the hopper to a 42-inch Meco Rockmaster single-roll crusher. Barium carbonate is added manually to the feed hopper at the rate of 7 pounds per ton of shale. The minus 4-inch crusher discharge is stored in a 1,000-ton bin and is fed by demand from 3 discharge points to the 3 drypans. One of these is a 9-foot Berg, one a 10-foot Maximuller drypan, and the third is a new Huber Warco rim discharge grinder. The drypans are in closed circuit with 4 Leahy vibrating and heated, 5-foot by 8-foot, 16 mesh screens, and the ground shale is stored in a second 1,000-ton storage bin.


UNIT
SAMPLE
HT.
NORTH WALL
Scale 1 inch to 10 feet
39.0'
34.2'
25.5'
17.2'
11.2'
0.0'
BE 5
BE 4
BE 3
BE 2
BE 1
③
②
①
DUNDAS FORMATION (HUMBER MEMBER)
Medium grain yellow sand
Shale fragments in light grey mud
Thick bed of white weathering shale
2" mud seam
1/8" limy knots and lenses common
Brachiopods common
1/8" pale grey limy knots and lenses are common
Brachiopods common in limy bed
Pit floor
WHITE WEATHERED SHALE BED
UPPER SOFT SHALE BEDS
HARD LAYER
MIDDLE SOFT SHALE BEDS
HARD SANDY AND LIMY LENSES
LOWER SOFT SHALE BEDS
O.D.M. 3261

Unit		Thickness *(feet)*
BE 5	SHALE: Medium grey, weathering to light grey and white; deeply weathered mud and shale fragments at the top; thick bed of soft shale.	4.8
BE 4	SHALE: Dark green-grey, weathering to light grey; soft with minor thin hard layers; medium-bedded; thin knots and streaks of light grey limy shale.	8.7
BE 3	SHALE: Dark green-grey, weathering to light grey; moderately soft; thin and medium-bedded with an imperfect platy parting; thin knots and streaks of light grey limy shale.	8.3
BE 2	LIMY SANDSTONE: Hard, thin-bedded, grey and brown, sandy and limy lenses interlayered with shale; hard layers comprise 50 percent of the unit.	6.0
BE 1	SHALE: Dark green-grey, weathering to light grey; moderately soft; thin and medium-bedded with platy parting; rare hard sandy layers	11.2

Figure 3—Booth Brick Ltd., Etobicoke quarry section.

TABLE 13 Chemical Analyses: Booth Brick Limited, Etobicoke Quarry

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–11.2	11.2–25.5	25.5–34.2	0.0–34.2
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				55.07
Al_2O_3				15.4
Fe_2O_3	6.85	6.62	6.80	6.97
CaO	4.51	5.22	3.77	4.70
MgO				3.07
Na_2O				0.90
K_2O				3.64
TiO_2				0.91
CO_2				4.31
H_2O +				3.23
H_2O −				0.79
SO_3				0.70
TOTAL				99.7
Loss on ignition	7.73	8.03	7.36	8.18
Soluble salts	0.77	0.76	0.68	

TABLE 14 Mineral Analyses: Booth Brick Limited, Etobicoke Quarry
(A = abundant; B = moderate; ND = not detected)

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–11.2	11.2–25.5	25.5–34.2	0.0–34.2
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	25	26	25	28
Calcite	5	5	3	5
Dolomite	<0.5	3	<0.5	3
Soda-lime Feldspar	3	3	2	2
Potash feldspar	2	<0.5	3	<0.5
Clay minerals				
Illite	A	A	A	A
Chlorite	B	B	B	B
Expanding minerals	ND	ND	ND	ND

TABLE 15 Ceramic Tests: Booth Brick Limited, Etobicoke Quarry

SAMPLE 1: 0.0′–11.2′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.5
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.7	2.2
Colour	salmon	salmon-pink	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	12.4	10.2	4.0
5-hour boil absorption (%)	13.9	12.0	6.1
Specific gravity	1.97	2.03	2.12

REMARKS: All briquettes are marked by a fine white specking. Briquettes are overfired at cone 03.

SAMPLE 2: 11.2′–25.5′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.0
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3	0.5
Colour	light salmon	salmon	brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)		12.8	8.0
5-hour boil absorption (%)		15.7	11.8
Specific gravity		1.90	1.90

REMARKS: Briquettes are friable at low firing temperatures; those fired at cone 010 gradually disintegrated on exposure to the atmosphere. Briquettes are blistered and slightly overfired at cone 03.

SAMPLE 3: 25.5′–34.2′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.1
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	1.2	2.5
Colour	light salmon	salmon	dark brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	11.8	9.6	2.7
5-hour boil absorption (%)	13.2	11.2	4.2
Specific gravity	1.98	2.06	2.10

REMARKS: All fired briquettes are marked by a fine white specking At cone 03 the briquettes are slightly blistered and overfired.

Disc feeders from 3 discharge points beneath the bin feed conveyor belts leading to the brick circuit or to a smaller bin for truck-loading of the ground shale for delivery to the North York plant. An F-R-H double-shaft, de-airing, auger machine extrudes a single stream that is cut by a J. C. Steele No. 18 cutter. Brick are hacked directly on kiln cars.

A 12-track waste-heat tunnel dryer can accommodate 12 cars on each track. Drying time is 48 hours at 250°F. Two tunnel kilns, 350 and 250 feet long, produce fired brick at the rate of 27 cars and 18 cars per day respectively. Both kilns are gas-fired. Firing temperature is 1880°F and flashing is possible in both kilns.

Shipments are made by truck and rail.

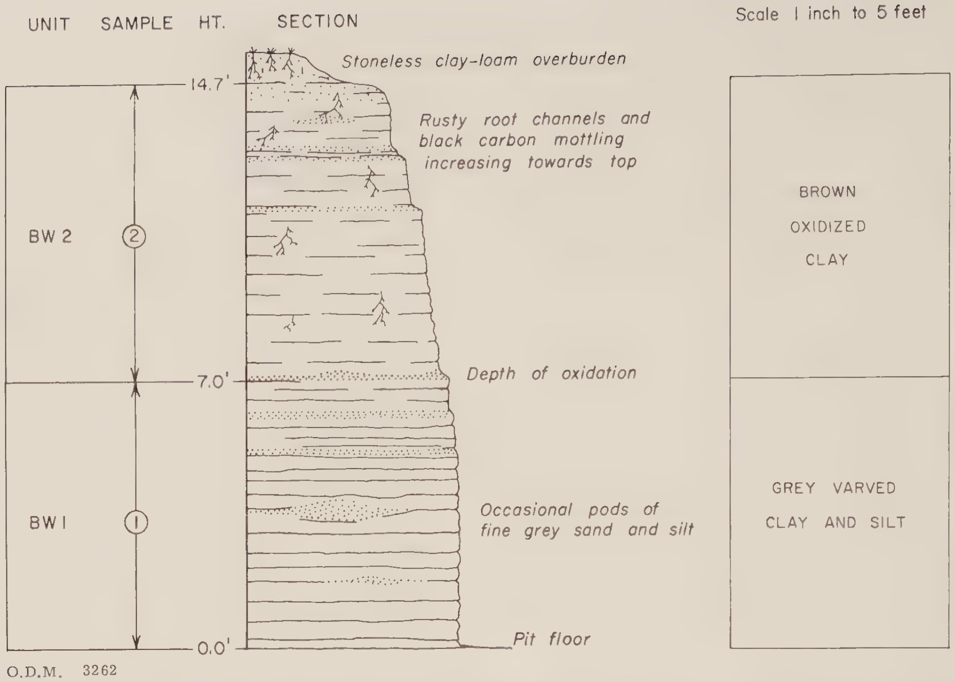
GEOLOGY

The 52-foot quarry face exposes dark green-grey, moderately soft, thin and medium-bedded shale, interlayered with a few hard limy and sandy lenses. The section belongs to the Humber Member of the Dundas Formation. A 37-foot section measured on the north wall of the quarry is illustrated in figure 3. Geological descriptions of the rock units, and the results of chemical, mineralogical, and ceramic testing of channel samples from the quarry face, are given in tables 13, 14, and 15.

North York Plant

The capacity of the North York plant is 25 million brick annually. Production is 90 percent "Ontario" size in a full range of colours and textures. Norman, SCR, Modular, and American bricks are also made. The operation employs about 40 men.

Ground Dundas shale is received by truck from the Etobicoke plant. Clay is removed from a small pit several hundred feet east of the North York plant and is stored separately. The two raw materials are batched by a 2-yard side-dump rail car feeding a bin above a 10-foot Riederwerke wet pan muller. Further grinding is accomplished by a Handle double-roll crusher. The feed is delivered without screening to a 9-foot pug mill ahead of the F-R-H combined pug, de-airing, and auger machine. The stream is extruded under a vacuum of 28 inches and is cut by a Steele No. 18 cutter. The brick are hacked 550 per car. A Hercules No. 12 soft-mud machine with a capacity of 25,000 brick per day has been idle for some years but may be used again.


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
Stoneless clay-loam overburden
14.7'
Rusty root channels and black carbon mottling increasing towards top
BW 2
②
BROWN OXIDIZED CLAY
7.0'
Depth of oxidation
GREY VARVED CLAY AND SILT
BW 1
①
Occasional pods of fine grey sand and silt
0.0'
Pit floor
O.D.M. 3262

Unit		Thickness (*feet*)
BW 2	CLAY: Medium grey clay and light grey silt, weathered medium brown and dark yellowish orange respectively; smooth and silty; stoneless; laminated to very thin-bedded; heavy rusting along root channels; black carbon mottling; silt increasing towards top.	7.7
BW 1	CLAY: Medium grey, drying very light grey; smooth except for silty layers; stoneless; varved; light grey silt on bedding planes is occasionally concentrated in pods up to 12 inches thick.	7.0

Figure 4—Booth Brick Ltd., North York pit section.

TABLE 16 Chemical Analyses: Booth Brick Limited, North York Pit

Sample	1	2	Composite
Height above floor (*feet*)	0.0–7.0	7.0–14.7	0.0–14.7
	(*percent*)	(*percent*)	(*percent*)
SiO_2			41.87
Al_2O_3			10.0
Fe_2O_3	4.17	4.38	3.79
CaO	19.7	18.2	19.1
MgO			2.72
Na_2O			1.18
K_2O			2.53
TiO_2			0.59
CO_2			12.28
H_2O+			1.84
H_2O-			0.64
SO_3			0.71
		TOTAL	100.2
Loss on ignition	17.29	17.42	18.07
Soluble salts	0.90	0.76	

TABLE 17 Mineral Analyses: Booth Brick Limited, North York Pit

(B = moderate; C = minor; ND = not detected)

Sample	1	2	Composite
Height above floor (*feet*)	0.0–7.0	7.0–14.7	0.0–14.7
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	16	22	23
Calcite	25	25	29
Dolomite	6	3	5
Soda-lime feldspar	3	2	4
Potash feldspar	<0.5	ND	2
Amphibole	<1	ND	ND
Clay minerals			
Illite	B	B	B
Chlorite	B	B	B
Expanding minerals	ND	ND	C

A 3-track waste-heat tunnel dryer above the kiln is 600 feet long. Each track holds 85 cars. Drying time is 48 hours and temperature at the hot end is 400°F. Total drying capacity is 80,000 brick per day. The dryer cars are lowered by hydraulic lift to parallel tracks beside the Booth-designed tunnel kiln where the brick are re-hacked 2,400 per kiln car. The 530-foot kiln holds 79 cars. A 60-minute push provides a daily production of close to 60,000 brick. The kiln is gas-fired to peak temperatures of 1870°F (red brick) or 1930°F (buff brick).

Shipments are made by truck or rail in cubes of 500 brick.

TABLE 18 Ceramic Tests: Booth Brick Limited, North York Pit

SAMPLE 1: 0.0′–7.0′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	4.5
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.7 (expansion)	0.7 (expansion)
Colour	cream-pink	cream	buff-white
Hardness	almost hard	almost hard	almost hard
24-hour absorption (%)	21.6	23.2	22.1
5-hour boil absorption (%)	21.7	25.0	25.6
Specific gravity	1.61	1.58	1.60

SAMPLE 2: 7.0′–14.7′

Water of plasticity (*percent*)	23
Lineal drying shrinkage (*percent*)	4.5
Pyrometric cone equivalent	2

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3 (expansion)	0.3 (expansion)
Colour	light salmon	cream	buff-white
Hardness	moderately hard	moderately hard	almost hard
24-hour absorption (%)	21.1	21.5	21.5
5-hour boil absorption (%)	22.0	23.0	24.5
Specific gravity	1.65	1.61	1.63

REMARKS: Both samples are moderately plastic, open-firing clays. Slight expansion, rather than shrinkage, occurs at higher firing temperatures. Fine hairline cracks are noticeable in most briquettes. Optimum firing point appears to be cone 03.

GEOLOGY

The clay pit exposes 15 feet of irregularly-varved clay and silt deposited towards the close of the Wisconsinan glacial stage in a shallow lake (Lake Peel) that was dammed against a lobe of ice in the Lake Ontario basin. The deposit has been oxidized to a depth of 7-8 feet. Less than 2 feet of clay-loam overburden, containing roots and sod, are removed by stripping. Similar clay extends for ½-mile on both sides of Highway No. 400 to 1 mile north of Sheppard Avenue (Watt 1957, map No. 1955–6).

Figure 4 illustrates a typical section in the pit. Geological descriptions of the clay, and the results of chemical, mineralogical, and ceramic testing of vertical channel samples, are given in accompanying tables.

DOMTAR CONSTRUCTION MATERIALS LIMITED: COOKSVILLE

Brick production at Cooksville began in 1911 when the Ontario National Brick Company constructed the present periodic kiln plant. Assets of the National Pressed Brick Company in Laprairie, Quebec, were purchased in the same year. After several re-organizations, and the building of another plant at Delson, Quebec, the company became known as the Cooksville Company in 1933. Dominion Tar and Chemical assumed control in 1953 and formed Cooksville-Laprairie Brick, Limited. The name was changed in early 1962 to Domtar Construction Materials Limited. The company presently operates two brick plants at Cooksville and one at Ottawa, Ontario. The company also has plants at Delson and Laprairie, Quebec. A plant producing dry-pressed brick was operated until 1964 at Cheltenham, Ontario. An expanded shale aggregate (Haydite) is also produced in a plant on the Cooksville property. Early descriptions of the Domtar plants are given by Montgomery (1930, pp. 144–147).

Periodic Kiln Plant

The two brick plants are located just west of Cooksville in lots 19 and 20, concession IS, Toronto township, Peel county. The periodic kiln plant is rated at 60 million brick or equivalent per year. The production includes all types of structural tile, quarry tile, acid-resisting brick, etc., as well as a full range of face brick including flashed colours not possible in the tunnel kiln plant. The plant employs 230 men on a year-round basis.

Breaking and hauling of the Dundas shale is contracted. The quarry adjoins the plants on the east side and is worked in two benches. Sections of the shale are drilled off at 8- or 10-foot spacing, and are lightly blasted to loosen the face. Diesel shovels load three 15–20 ton quarry trucks for the ¼-mile haul to the plant. Some of the hard limy or sandy layers are sorted manually during the loading operation; the rest are removed on a picking belt at the plant. The trucks dump into a large hopper which feeds shale uniformly onto the picking belt, the belt discharging in turn through a heavy single-roll crusher. The minus 3-inch discharge is coarse-screened on multideck screens. The intermediate sizes go to the Haydite plant while the oversize and undersize are retained for the brick circuit. An overhead electric crane with clam bucket reclaims crushed shale from a large raw material storage shed and loads the drypan feeders. The 10-foot diameter drypans are load-controlled by automatic feeders, each pan and feeder operating independently. A battery of 4-foot by 10-foot electrically heated vibrating screens are in closed circuit with the drypans. Minus 14 mesh material goes to storage bins ahead of the forming equipment. Four independent production lines are equipped with pug-mill, combined pug and de-airing and auger machine, automatic cutter, conveyor belt, and hacking facilities. De-airing is accomplished at 25–27 inches of vacuum. Additives for colour control are introduced in slurry form in the pugging section. Tempering of the dry shale is completed with the addition of 10–12 percent water. The extruded column can be textured or sanded in the normal way.

The green ware are hacked on cars and held in a storage area ahead of the dryers. There are two dryers, each made up of two independent units having 14 tunnels per unit. The tunnels are about 100 feet long and hold 16 cars each. They are gas-fired, and each unit of 14 tunnels is separately controlled for temperature and humidity. Temperatures at the hot end vary from 180°F for tile to 225°F for brick. Drying time is about 40 hours. Firing is accomplished in 3 continuous chamber kilns or 7 periodic rectangular kilns. The ware are manually set in both types. The chamber kilns, known as Youngrens, are each composed of 16 chambers in two rows of 8 back to back. The chambers are interconnected by a flue system which allows preheated air drawn from a chamber in the cooling cycle to be used as combustion air for the adjacent chamber under fire. The exhaust gases from the latter serve in turn to preheat the adjacent chamber next in line to be fired. Each chamber has a capacity for 70,000 brick and the firing temperature is about 1900°F. Five of the rectangular downdraft periodic kilns have capacities of 100,000 brick each and are turned over on 2-week cycles. Two smaller rectangular kilns are used for specialty ware in relatively small volume production. All kilns are gas-fired.

Brick are palletized in 500-brick cubes. Finished ware are stored in the yard and shipped by truck or rail.

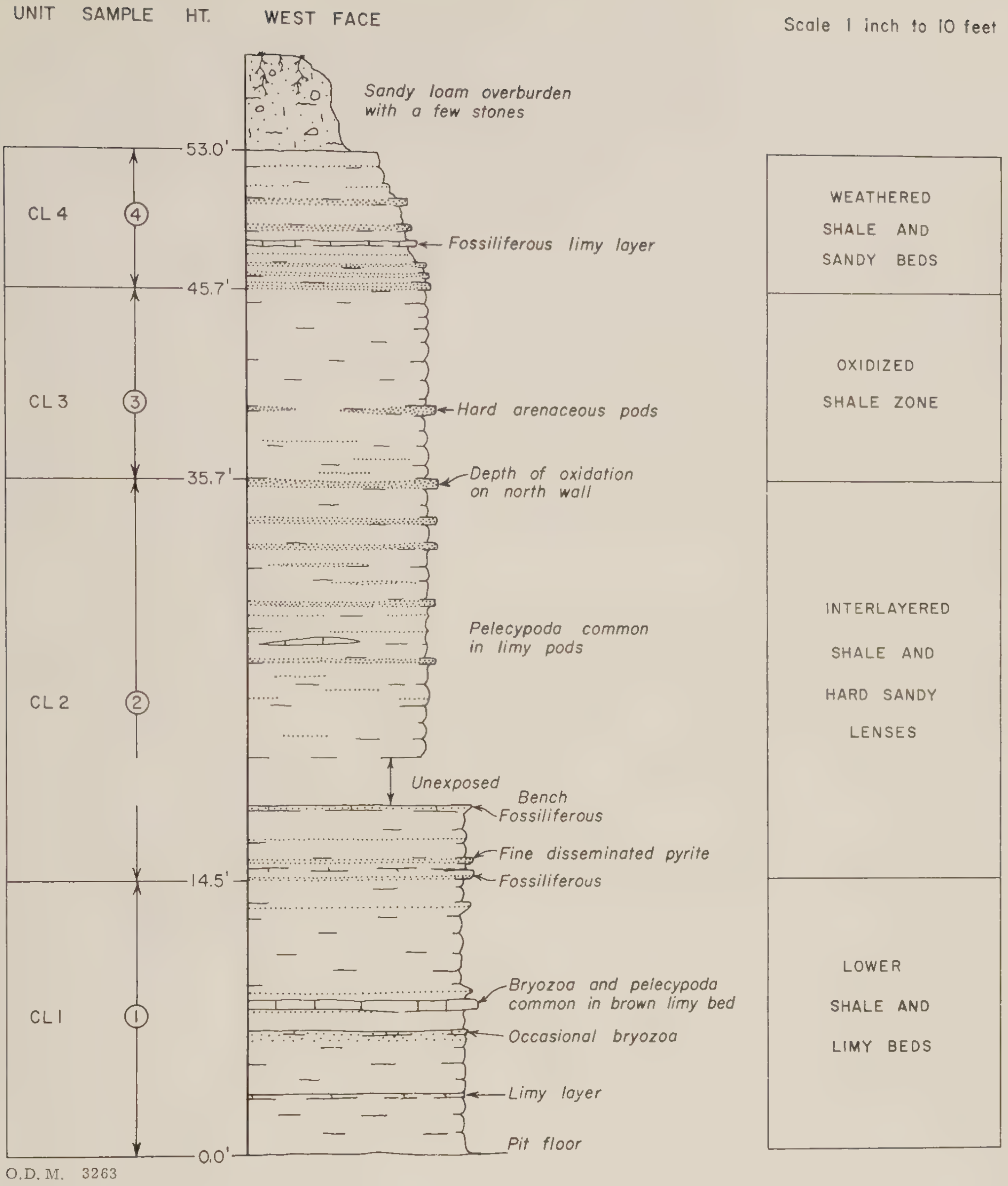
Tunnel Kiln Plant

The new tunnel kiln plant was completed in 1959. It adjoins the periodic kiln plant but is completely independent of it. Annual production is rated at 24 million brick, and 40 men are employed on a year-round basis. The new Cooksville plant and the tunnel kiln plant at Ottawa are almost identical in equipment and design.

Dundas shale is received in a hopper at the plant and is conveyed by apron feeder to a single-roll crusher. The minus 4-inch crusher discharge is stored in 2 wooden bins, each of 200-ton capacity. Two fully enclosed 10-foot drypans are each in closed circuit with 3 heated vibrating screens. The 16-mesh screen cloths are 4 by 10 feet in size. Sized material is conveyed to one of four 100-ton storage bins. Feed for the brickmaking equipment is discharged to a conveyor by disc feeders below the storage bins. Various additives such as barium carbonate, limestone, zinc, and manganese are added as required for colour and scum control. An electronic proportioning system is based on weights recorded by a scale on the feed conveyor assuring constancy of the predetermined mix. Some 10–15 percent water is added for tempering in the first pug mill. A large combined pugging, de-airing, and auger machine extrudes brick at the rate of 15,000 per hour. Texturing or sanding is applied to the green column immediately following extrusion. The stream is cut by an automatic cutter making 21 bricks each cycle. The brick are hacked 4,000 to a car and are not re-handled until the drying and burning processes have been completed.

Green brick are stored in a hot room under conditions of constant temperature and humidity. After leaving the hot room the brick are dried for about 48 hours. The 2 drying tunnels have capacities for 17 cars each and are heated by waste-heat augmented by gas. The single tunnel kiln holds 38 cars and produces finished brick at the rate of 70,000 per day. An hydraulic pusher is controlled to discharge one car every 95 minutes. Temperatures in the kiln range to 1900–1950°F in the heat zone. After a total elapsed time of 53 hours in the kiln the ware is discharged at a temperature of 150°F. Firing is by gas.

The brick are sorted for colour and quality and palletized in 500-brick cubes. Forklift trucks stock the cubes in the yard or load trucks for shipment.


UNIT
SAMPLE
HT.
WEST FACE
Scale 1 inch to 10 feet
Sandy loam overburden with a few stones
53.0'
CL 4
④
Fossiliferous limy layer
45.7'
CL 3
③
Hard arenaceous pods
35.7'
Depth of oxidation on north wall
Pelecypoda common in limy pods
CL 2
②
Unexposed
Bench
Fossiliferous
Fine disseminated pyrite
14.5'
Fossiliferous
Bryozoa and pelecypoda common in brown limy bed
CL 1
①
Occasional bryozoa
Limy layer
Pit floor
0.0'
WEATHERED SHALE AND SANDY BEDS
OXIDIZED SHALE ZONE
INTERLAYERED SHALE AND HARD SANDY LENSES
LOWER SHALE AND LIMY BEDS
O.D.M. 3263

Unit		Thickness (*feet*)
CL 4	SHALE: Dark yellow-brown, weathering to buff; deeply weathered, alternately soft and hard beds; thin and medium-bedded; abundant hard sandy layers; some white efflorescence.	7.3
CL 3	SHALE: Dark yellow-brown, weathering to grey-buff; soft; thin bedded; hard sandy layers rare; some rusty oxidation; white efflorescence.	10.0
CL 2	SHALE: Dark green-grey, weathering to medium green-grey; soft shale with common hard sandy layers; very thin to medium-bedded, weathering with a platy parting; sandy beds are mottled with white and buff spots, and some rusty disseminated pyrite.	21.2
CL 1	SHALE: Dark green-grey, weathering to medium grey; soft with occasional hard layers; thin and medium-bedded with platy to fissile parting; hard layers are either grey sandy beds or brown fossiliferous limy beds; white efflorescence is fairly common.	14.5

Figure 5—Cooksville, quarry section.

TABLE 19 Chemical Analyses: Cooksville Quarry

Sample	1	2	3	4	Composite
Height above floor (*feet*)	0.0–14.5	14.5–35.7	35.7–45.7	45.7–53.0	0.0–53.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2					55.55
Al_2O_3					14.4
Fe_2O_3	6.37	5.82	6.55	5.75	6.17
CaO	4.23	6.02	4.88	5.60	5.17
MgO					2.84
Na_2O					0.94
K_2O					3.57
TiO_2					0.83
CO_2					4.71
H_2O+					3.22
H_2O-					0.84
SO_3					0.49
TOTAL					98.7
Loss on ignition	7.46	9.08	8.49	9.30	8.84
Soluble salts	0.96	0.76	0.90	0.62	

TABLE 20 Mineral Analyses: Cooksville Quarry
(A = abundant; B = moderate; ND = none detected)

Sample	1	2	3	4	Composite
Height above floor (*feet*)	0.0–14.5	14.5–35.7	35.7–45.7	45.7–53.0–	0.0–53.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals					
Quartz	27	31	27	27	26
Calcite	7	7	5	10	6
Dolomite	ND	ND	3	ND	1
Soda-lime feldspar	4	3	2	3	3
Potash feldspar	1	<0.5	ND	ND	ND
Amphibole	<0.5		<0.5		
Clay minerals					
Illite	A	A	A	A	A
Chlorite	B	B	B	B	B
Expanding minerals	ND	ND	ND	ND	ND

A plant expansion program is currently underway, in which a second, similar dryer and tunnel kiln with the associated equipment are being installed. Startup is scheduled for January 1966. This addition will double plant capacity to 48 million brick annually. Present grinding and millroom facilities will remain unchanged, but will be doubleshifted to provide the necessary green ware.

Haydite Plant

An expanded shale aggregate is made in a plant adjoining the two Domtar brick plants at Cooksville. The material, known as "Haydite," after its inventor S. J. Hayde, has been produced at Cooksville since 1928.

The annual capacity of the plant is close to 150,000 yards of expanded shale. After firing, the clinker is crushed and screened to various product sizes:

(1) minus 1 inch plus ¾ inch
(2) minus ¾ inch plus ½ inch
(3) minus ½ inch plus ¼ inch
(4) sand (minus ¼ inch)

The volume expansion on firing is about 100 percent, resulting in an aggregate weighing 38 to 40 pounds per cubic foot. Greatest demand is for the sand-size aggregate. Seven men are employed in the plant.

Dundas shale is trucked to a hopper at the periodic kiln plant, where hard limy and sandy fragments are

TABLE 21 Ceramic Tests: Cooksville Quarry

SAMPLE 1: 0.0′–14.5′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.7
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5	1.2	1.4 (expansion)
Colour	light salmon	salmon	dark brown
Hardness	hard	very hard	very hard
24-hour absorption (%)	11.4	9.5	1.3
5-hour boil absorption (%)	13.5	11.8	3.4
Specific gravity	1.95	2.00	1.91

REMARKS: A fine white specking is common on all fired briquettes. Briquettes are overfired at cone 03 and are slightly bloated and blistered.

SAMPLE 2: 14.5′–35.7′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.0
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3 (expansion)	1.7
Colour	light salmon	light salmon	brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)	16.1	13.7	6.9
5-hour boil absorption (%)	17.8	16.2	10.2
Specific gravity	1.84	1.88	1.97

REMARKS: A fine white specking is common on all fired briquettes. Briquettes are blistered and slightly overfired at cone 03.

SAMPLE 3: 35.7′–45.8′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.2
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980
Lineal firing shrinkage (%)	0	0.5	2.0
Colour	light salmon	salmon	brown
Hardness	hard	hard	very hard
24-hour absorption (%)	13.3	11.7	5.6
5-hour boil absorption (%)	14.9	13.6	7.8
Specific gravity	1.93	1.97	2.05

REMARKS: A fine white specking is common on all fired briquettes. Briquettes are blistered and overfired at cone 03.

SAMPLE 4: 45.7′–53.0′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	2.4
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.1	2.4
Colour	salmon	salmon-red	red-brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)	16.3	13.5	7.8
5-hour boil absorption (%)	17.9	15.8	11.2
Specific gravity	1.84	1.89	2.01

REMARKS: A fine white specking is common on all fired briquettes. At cone 03 briquettes are slightly blistered and overfired.

picked from a belt before the shale is passed through a large single-roll crusher. The minus 3-inch discharge is screened into three sizes on multi-deck screens. The intermediate range is conveyed to the Haydite plant, while the oversize and undersize are retained for the brick circuit.

A large steel storage silo with a capacity equivalent to 1,200 yards of expanded clinker, provides raw shale for the 3 rotary gas-fired kilns. The shale is elevated to the kilns from three draw points in the bottom of the silo. Two of the kilns are 50 feet long and 6 feet in diameter; the other is 7 feet in diameter and 60 feet long. Shale enters the cold end of the kilns and is discharged at the hot end after 20 minutes. Heat flow is counter to the direction of feed travel and the kilns rotate at about 1 revolution per minute. Temperature at the hot end is 2100–2200°F and is visually controlled by the fireman to initiate bloating at a point about 10 feet from the discharge point. In the final bloating zone stickiness becomes pronounced and large sem-plastic fragments of clinker are discharged via inclined chute to the cooling pit. Much depends on the ability of the fireman in controlling the temperature so as to ensure maximum bloating and optimum agglomeration at discharge. Cooling water is sprayed on the outside shell

PANDA 59787-7

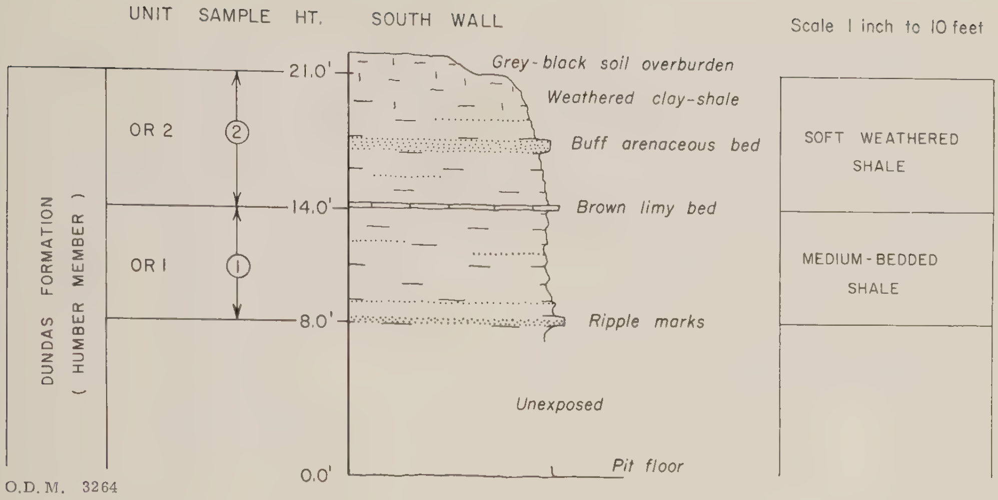
Photo 16—Dundas shale at Cooksville, 1959. (Photo by Panda, Toronto; courtesy of Canadian Structural Clay Association, Willowdale.)

at the hot end of the kilns to minimize heat damage to the steel shell.

A diesel shovel with a 1¼-yard clam bucket periodically removes the hot clinker from the pit and stockpiles it for 24-hour cooling. It is then loaded by the same clam into a 50-yard hopper feeding a large single-roll toothed crusher. Two double-deck 4-foot by 8-foot heated vibrating screens have interchangeable screen cloths to provide the finished product sizes as the demand requires. Secondary grinding is accomplished by two 20-inch diameter 24-inch, smooth double-roll crushers in closed circuit with the screens. Four trestle-mounted belt conveyors transfer the variously sized products simultaneously to stockpiles. Front-end loaders maintain the supply of each size at sub-grade draw points, where weight-proportioning feeders supply any predetermined blend to a sub-level loading conveyor. Shipments are made in bulk or bag by truck or rail.

Geology

The upper part of the Dundas Formation outcrops in the vicinity of Cooksville, where a 53-foot section of the Humber Member is exposed in a quarry on the north side of Highway No. 5. The quarry is worked in two benches; the lower bench is 20 feet thick and the upper has a maximum thickness of 33 feet. The upper bench is oxidized from surface to a depth of 17 feet. The section is described and illustrated in figure 5. Chemical, mineralogical, and ceramic characteristics, based on vertical channel samples, are given in tables 19, 20, and 21.


UNIT
SAMPLE
HT.
SOUTH WALL
Scale 1 inch to 10 feet
21.0'
14.0'
8.0'
0.0'
OR 2
OR 1
②
①
DUNDAS FORMATION
(HUMBER MEMBER)
Grey-black soil overburden
Weathered clay-shale
Buff arenaceous bed
Brown limy bed
Ripple marks
Unexposed
Pit floor
SOFT WEATHERED SHALE
MEDIUM-BEDDED SHALE
O.D.M. 3264

Unit		Thickness (*feet*)
OR 2	SHALE: Green-grey, weathering buff; soft, deeply weathered; very thin-bedded; occasional hard layers or lenses; shale becomes progressively weathered to clay towards top.	7.0
OR 1	SHALE: Dark green-grey, weathering light grey; soft; medium-bedded with a platy to fissile parting; ripple marks on rare sandy beds; minor white efflorescence.	6.0

Figure 6—Ontario Reformatory, quarry section.

TABLE 22 Chemical Analyses: Ontario Reformatory

Sample	1	2	Composite
Height above floor (*feet*)	8.0–14.0	14.0–21.0	8.0–21.0
	(*percent*)	(*percent*)	(*percent*)
SiO_2			56.75
Al_2O_3			15.4
Fe_2O_3	6.85	6.47	6.55
CaO	4.80	3.55	3.81
MgO			2.63
Na_2O			0.91
K_2O			3.46
TiO_2			0.92
CO_2			2.70
H_2O+			3.70
H_2O-			1.59
SO_3			0.57
		TOTAL	99.0
Loss on ignition	7.93	8.37	8.13
Soluble salts	0.64	0.75	

TABLE 23 Mineral Analyses: Ontario Reformatory
(A = abundant; B = moderate; C = minor;
ND = not detected)

Sample	1	2	Composite
Height above floor (*feet*)	8.0–14.0	14.0–21.0	8.0–21.0
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	29	31	31
Calcite	4	4	5
Dolomite	<0.5	ND	<0.5
Soda-lime feldspar	5	<0.5	3
Potash feldspar	ND	ND	<0.5
Clay minerals			
Illite	A	A	A
Chlorite	B	B	B
Expanding minerals	ND	C	C

ONTARIO REFORMATORY

A plant producing brick and structural tile is operated by the Ontario Government on Horner Avenue, New Toronto. The plant provides work for the inmates of the reformatory school, and the products are used entirely for government constructions. It was started in 1911 and largely rebuilt in 1949–50. Early descriptions of the plant and shale are given by Keele (1924, pp. 18–19) and Montgomery (1930, p. 168).

Plant

Average annual production is 3 million brick and 1 million tile of various types and sizes. No attempt is made to maintain a high rate of production as the purpose of the plant is primarily to provide employment and teaching. The plant is well equipped and very clean.

The quarry is worked in ledges and the shale is taken largely by pick and shovel. In especially hard sections the face is sometimes drilled by jackhammer on a 3 × 3-foot spacing to a depth of 18 feet, and the section is broken using 40 percent dynamite. Broken shale is allowed to weather for 6 to 12 months

TABLE 24 Ceramic Tests: Ontario Reformatory

SAMPLE 1: 8.0′–14.0′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.0
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.5	2.0
Colour	light salmon	salmon	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	13.8	11.9	5.9
5-hour boil absorption (%)	15.6	13.4	8.6
Specific gravity	1.92	1.98	2.04

REMARKS: Fired briquettes are marked by minor white scum. The shale is overfired at cone 03; briquettes are dark coloured, blistered, and dense.

SAMPLE 2: 14.0′–21.0′

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	4.5
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5	2.8	6.3
Colour	salmon	salmon-red	dark red
Hardness	hard	very hard	very hard
24-hour absorption (%)	14.2	10.1	1.5
5-hour boil absorption (%)	15.4	12.4	2.9
Specific gravity	1.88	2.00	2.31

REMARKS: Fired briquettes are marked by fine white specking and a little scum. Shale is overfired at cone 03, but not deformed or blistered.

before use. A 1½-yard car travelling on a circular track around the periphery of the pit floor is loaded by hand and dumped on a 6-inch square-mesh grizzly. Weathering reduces most of the shale fragments sufficiently to pass the grizzly; hard over-size fragments are discarded. A 220-foot inclined conveyor belt, 24 inches wide, conveys the shale out of the pit and into a 550-ton reinforced concrete storage silo. A few feet of soft weathered shale or surface clay is proportioned in the feed from the pit. When making brick, about 30 percent clay is added to the shale; 50 percent clay is added for structural tile. Two draw points beneath the crude storage silo provide clay and shale for two identical lines of sorting, grinding, and screening. The 42-inch picking belts are portable units which can be stored beneath the silo when not required. Each belt discharges to a 9-foot Clearfield drypan which is in closed circuit with a single Leahy vibrating screen. Screen cloths are interchangeable; a 30-mesh heated screen is used for partition tile; a 14-mesh unheated screen is used for structural tile; and an 8-mesh unheated screen is used for brick. Three steel silos, each of 150 tons capacity, store the various sizes separately. One is further partitioned for additional separate storage if required.

There are 3 independent forming circuits fed by Meco disc feeders. The brick circuit consists of a Parkhill double-shaft pug mill, and F-R-H Junior combined pug, de-airing, and auger machine, and a Steele No. 18 cutter. Brick are extruded under a vacuum of 25 inches, and are textured in rug, tapestry, or smooth finish. The circuit for structural tile consists of a Plymouth single-shaft pug mill, and American 404A combined pug, de-airing, and auger machine, and a Steele cutter. Drain and soffit tile are made in a circuit consisting of a 7-foot Berg wet pan with a Wynn unloader, an F-R-H Plymouth Special pug, de-airing, auger machine, and a Frey Universal cutter. The green ware is hacked on cars, 500 brick or equivalent per car.

Drying is accomplished in 5 tunnel dryers of 3 tracks each, holding 14 cars per track. Steam heat is provided by the central heating unit in the Reformatory. Drying is humidity-controlled by a Robinson ventilating system. Temperature of the ware is increased from 90°F at the discharge end over a 5-day drying period. There are 5 rectangular downdraft kilns of various sizes, ranging in capacity from 20,000 to 75,000 brick each. They are fired with gas to peak temperatures of 1820° to 1835°F. The best turnover cycle is about 3 weeks.

Shipments are made by truck or rail.

GEOLOGY

The quarry is 21 feet deep, but only the top 13 feet was exposed at the time of the writer's visit. The shale section is typical of the Humber Member of the Dundas Formation. It is illustrated and described in figure 6. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 22, 23, and 24.

TORONTO BRICK COMPANY, LIMITED

The Don valley plant of Toronto Brick Company, Limited, is one of the earliest brick plants in the Toronto area still operating at the same location. Built in 1889 it was acquired by the present management in 1956. During the last few years it has been completely renovated, and a new sand-lime brick plant has been added. A sketch of the plant layout is given in figure 7. Early descriptions are given by Baker (1906, pp. 111–112), Keele (1924, pp. 18–19, 106, 141), and Montgomery (1930, pp. 161–162).

Face brick with a wide range of colours and textures are made from two major raw materials plus the normal list of minor additives. In recent years the company has pioneered the development of glazed brick. Dundas shale and glacial varved clay is obtained from a cut in the valley wall just north of the plant. Reserves of the Don and Scarborough interglacial clays are now practically exhausted in the Don valley pit. Clay from the Scarborough Beds was valued because of the rich maroon-red colour of the fired bricks. The same clay was used in Toronto Brick Company's Price plant on Greenwood Avenue, until that plant was closed in 1962. A description of the former John Price plant is given in a later section. In addition to Dundas shale and glacial varved clay, Queenston shale was also used at the Toronto Brick Company's plant until 1964. It was trucked from a quarry near Milton, a description of which is included in the section on Queenston shale quarries.

The working face of Dundas shale in the Don valley quarry is 500 feet long. It is advanced in a northerly direction on two levels, and has cut 300 feet into the valley wall and 40 feet below the valley floor. Sections of the face are drilled off with vertical 2-inch diameter holes on a 6-foot by 6-foot spacing and burden, using a portable compressor and wagon drill. Blasting is done with 40 percent Forcite and electric delay caps. The broken shale is loaded into two 5-ton trucks by a ½-yard Dominion electric shovel. The shale is dumped via hopper to a mechanical conveyor in the primary crusher building on the pit floor. Manual sorting of hard limy and sandy fragments precedes discharge of the shale through a 36-inch diameter McCanahan single-roll crusher that reduces it to 3–4-inch fragments. A 400-foot inclined 18-inch belt conveys the broken shale from the quarry to a 150-ton primary storage area.

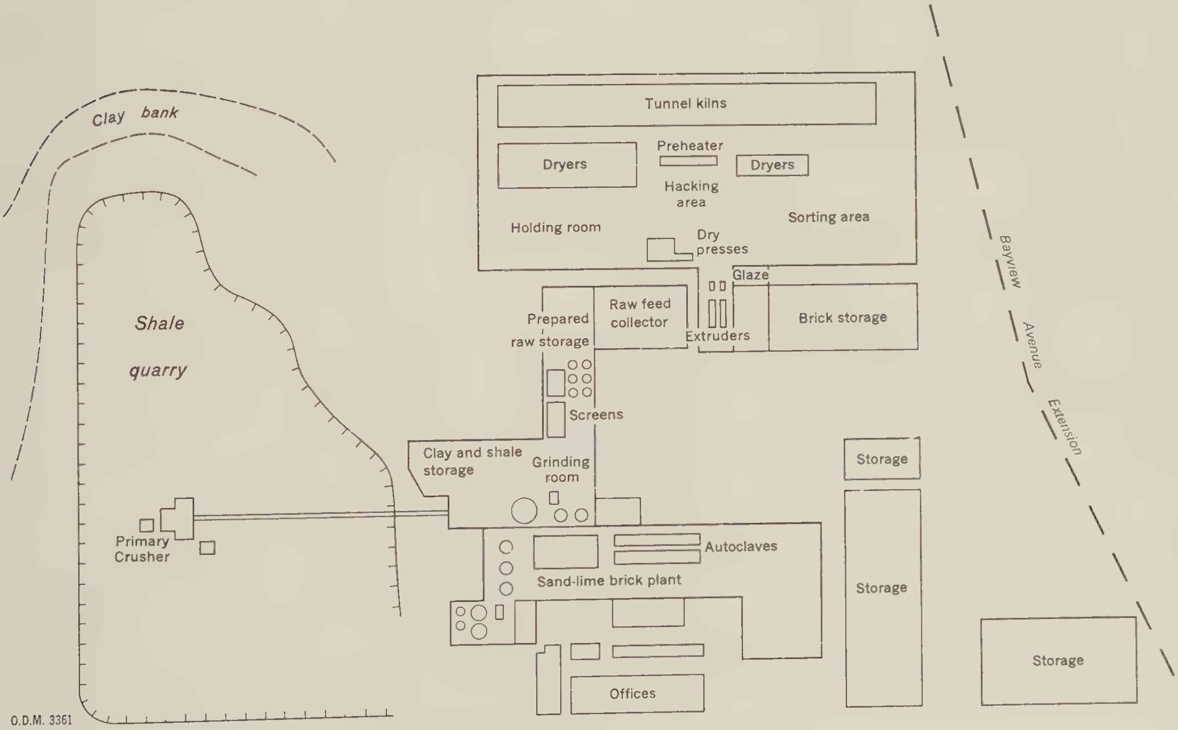

Clay bank
Shale quarry
Primary Crusher
Tunnel kilns
Dryers
Preheater
Dryers
Hacking area
Sorting area
Holding room
Dry presses
Glaze
Prepared raw storage
Raw feed collector
Extruders
Brick storage
Screens
Clay and shale storage
Grinding room
Autoclaves
Sand-lime brick plant
Offices
Storage
Storage
Storage
Bayview Avenue Extension
O.D.M. 3361

Figure 7–Toronto Brick Co. Ltd., Don Valley plant, 1963.

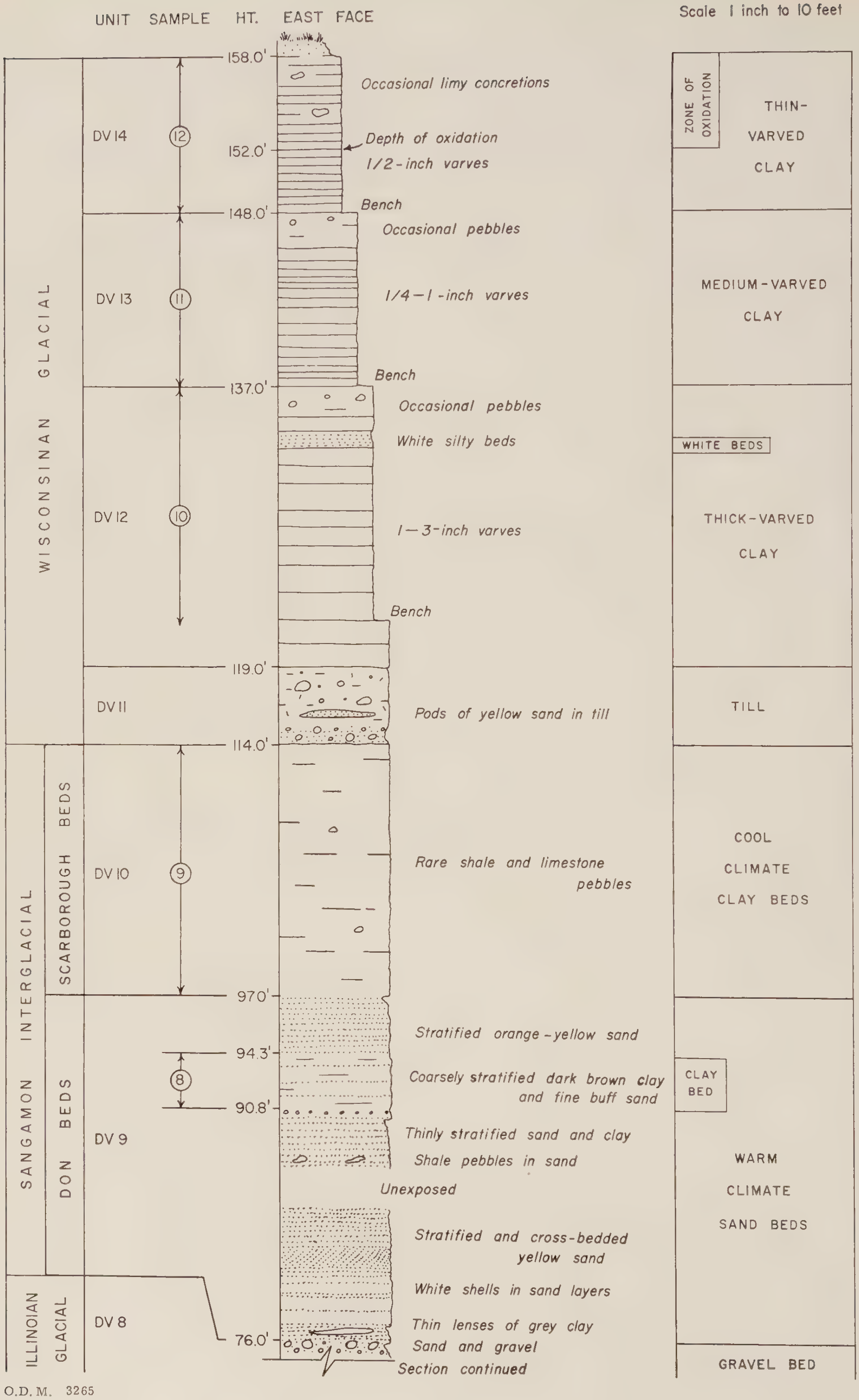

UNIT
SAMPLE
HT.
EAST FACE
Scale 1 inch to 10 feet
158.0'
152.0'
148.0'
137.0'
119.0'
114.0'
970'
94.3'
90.8'
76.0'
WISCONSINAN GLACIAL
SANGAMON INTERGLACIAL
SCARBOROUGH BEDS
DON BEDS
ILLINOIAN GLACIAL
DV 14
DV 13
DV 12
DV 11
DV 10
DV 9
DV 8
⑫
⑪
⑩
⑨
⑧
Occasional limy concretions
Depth of oxidation
1/2-inch varves
Bench
Occasional pebbles
1/4—1-inch varves
Bench
Occasional pebbles
White silty beds
1—3-inch varves
Bench
Pods of yellow sand in till
Rare shale and limestone pebbles
Stratified orange-yellow sand
Coarsely stratified dark brown clay and fine buff sand
Thinly stratified sand and clay
Shale pebbles in sand
Unexposed
Stratified and cross-bedded yellow sand
White shells in sand layers
Thin lenses of grey clay
Sand and gravel
Section continued
ZONE OF OXIDATION
THIN-VARVED CLAY
MEDIUM-VARVED CLAY
WHITE BEDS
THICK-VARVED CLAY
TILL
COOL CLIMATE CLAY BEDS
CLAY BED
WARM CLIMATE SAND BEDS
GRAVEL BED
O.D.M. 3265

Figure 8—Toronto Brick Co. Ltd., Don Valley clay section.

Description of Don Valley clay section, Toronto Brick Co. Ltd. (figure 8.)

Unit		Thickness (*feet*)
Wisconsinan Glacial		
DV 14	CLAY: Olive-grey clay and light grey silt; smooth, dense, tough, uniform $\frac{1}{2}$-inch varves. Upper 6 feet oxidized to medium brown clay and buff-yellow silt; becomes flaky when dry; buff limy concretions to 1-inch are occasional.	10.0
DV 13	CLAY: Olive-grey clay and light grey silt; smooth, dense, tough; $\frac{1}{4}$-1-inch varves; occasional pebbles locally present in a thick lenticular clay varve near the top of the section.	11.0
DV 12	CLAY: Olive-grey clay and light grey silt; smooth, dense, tough; 1-3-inch varves; about 50 percent clay, 50 percent silt; occasional rounded pebbles; several adjacent 3-inch varves are predominately silt, which when dry forms a prominent white marker horizon in the upper part of the section.	18.0
DV 11	SAND, GRAVEL, TILL: Mixed lenses and pods of medium-grained yellow sand, brown-grey till, and gravel; subrounded pebbles in gravel and till, mostly $\frac{3}{8}$–$\frac{3}{4}$ inches, consist of grey Paleozoic limestone, gneisses, siltstones and shales.	5.0
Sangamon Interglacial		
DV 10	SCARBOROUGH BED CLAY: Medium brown, drying to yellow-buff; uniform, dense, smooth, blocky; bedding barely discernible at 1–2-inch; fine lamination superimposed on bedding; rare shale and limestone pebbles; unit thickens to the south, pinches out to the north.	17.0
DV 9	DON BED SAND AND CLAY: Yellow sand and grey or brown clay; sand is fine-medium grained, stratified and cross-bedded; white shells (gastropods, pelecypods) locally common in sand beds; 4$\frac{1}{2}$-foot zone in upper part of unit consists of smooth, dense, dark brown clay interlaminated with fine buff sand or silt; bedding $\frac{3}{8}$–$\frac{3}{4}$ inch; occasional pebbles.	21.0
Illinoian Glacial		
DV 8	SAND, GRAVEL: Well-sorted medium-coarse sand and fine gravel.	3.0

TABLE 25 Partial Chemical Analyses:
Toronto Brick Company Limited, Don Valley

	Dundas Shale			
Sample	1	2	3	4
Height above floor (*feet*)	2.0–12.0	12.0–26.0	26.0–32.3	32.3–43.8
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Fe_2O_3	6.50	6.90	5.95	6.55
CaO	3.03	3.67	6.45	3.79
Loss on ignition	6.56	7.02	8.98	7.27
Soluble salts	0.75	1.02	0.72	0.72

	Dundas Shale		Don Bed Interglacial	
Sample	5	6	7	8
Height above floor (*feet*)	43.8–50.3	50.3–60.0	60.0–73.0	90.8–94.3
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Fe_2O_3	6.43	6.90	6.80	4.47
CaO	6.92	3.22	6.30	7.42
Loss on ignition	10.42	6.48	9.08	7.84
Soluble salts	0.68	0.72	0.70	0.65

	Glacial Varved Clays		
Sample	10	11	12
Height above floor (*feet*)	122.0–137.0	137.0–148.0	148.0–158.0
	(*percent*)	(*percent*)	(*percent*)
Fe_2O_3	4.52	4.22	4.40
CaO	21.5	18.0	16.9
Loss on ignition	18.14	17.94	17.56
Soluble salts	0.74	0.94	0.76

TABLE 26 Complete Chemical Analyses:
Toronto Brick Company Limited, Don Valley

	Dundas Shale	Scarborough Bed Interglacial (9)	Glacial Clay
Height above floor (*feet*)	2.0–73.0	97.0–114.0	122.0–158.0
	(*percent*)	(*percent*)	(*percent*)
SiO_2	55.28	59.58	40.07
Al_2O_3	15.9	13.9	10.4
Fe_2O_3	6.72	4.95	4.28
CaO	4.86	5.53	19.2
MgO	2.75	2.68	3.07
Na_2O	0.96	1.84	1.11
K_2O	3.39	2.75	2.20
TiO_2	0.89	0.65	0.62
CO_2	4.52	3.92	14.65
H_2O+	3.37	2.45	1.71
H_2O-	0.80	1.42	0.94
SO_3	1.37	0.49	0.62
TOTALS	100.8	100.2	98.9
Loss on ignition	8.28	7.76	17.66

Glacial varved clay is worked on three levels above the northeast corner of the shale quarry. A ⅞-yard Koering diesel shovel loads trucks for the downhill haul to the plant. The clay is crushed into 3- to 6-inch lumps and is conveyed either directly to the grinding and batching section or to a 3,000-ton clay storage area. If excessively wet, the lump clay may be dried in a Spengler oil-fired, tower-type, rotating dryer.

Clay and shale are delivered in batch proportions to two 8-foot American drypans. Ground material passes to six 4-foot by 7-foot electrically-heated Leahy vibrating screens in closed circuit with an Hasemag impactor. Feed for the stiff-mud extrusion machines is ground to 16-mesh; for the dry-press machines, 20-mesh. Four 80-ton silos provide storage for the ground material.

In the stiff-mud extrusion circuit clay-shale feed is delivered by disc feeder from an overhead surge bin to a 16-foot double-shaft F-R-H pugmill. Barium carbonate is added with the hot tempering water. Brick are produced at 16 percent moisture by two

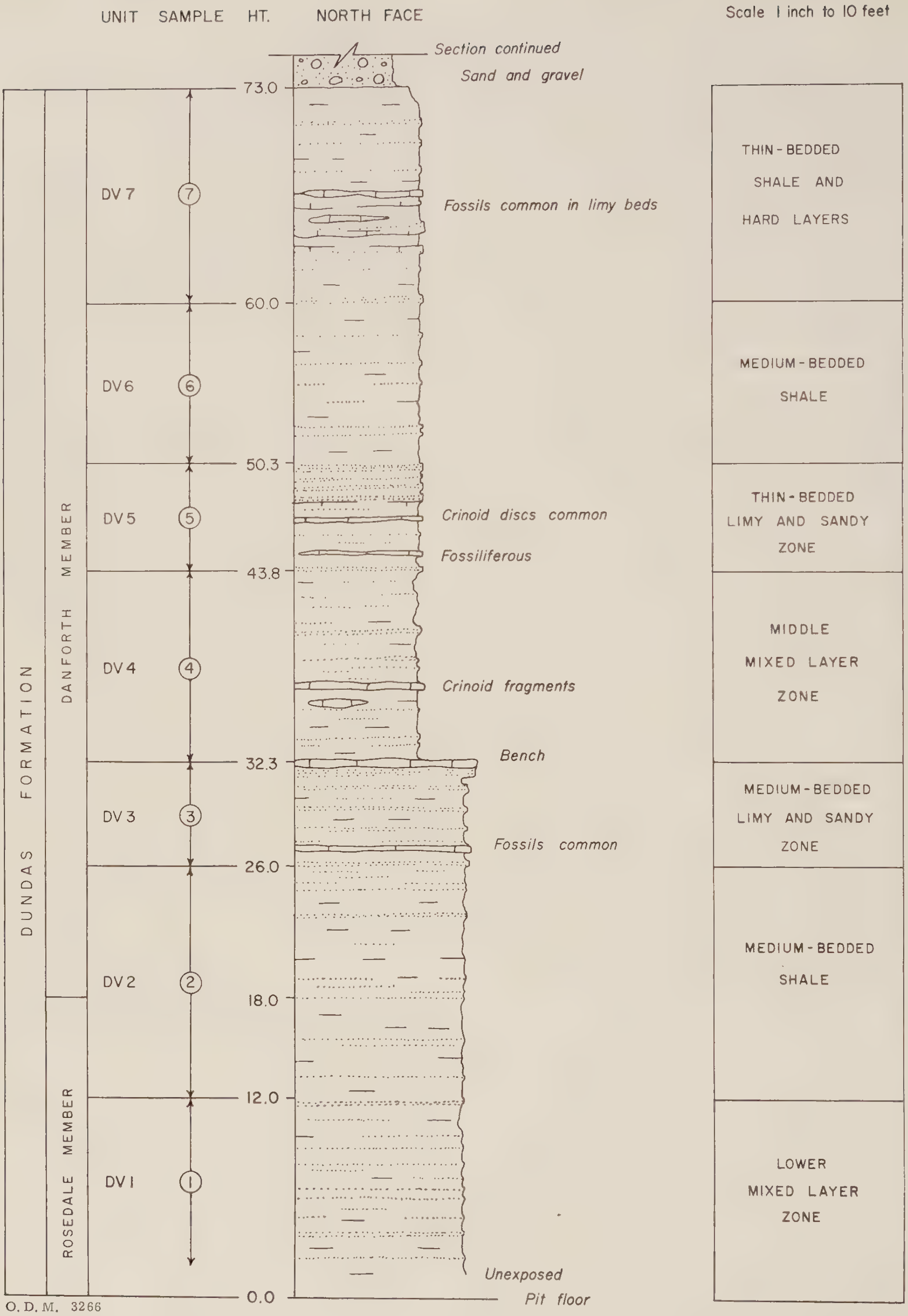

UNIT
SAMPLE
HT.
NORTH FACE
Scale 1 inch to 10 feet
Section continued
Sand and gravel
73.0
DV 7
7
Fossils common in limy beds
60.0
DV6
6
50.3
DV5
5
Crinoid discs common
Fossiliferous
43.8
DV4
4
Crinoid fragments
32.3
Bench
DV 3
3
Fossils common
26.0
DV 2
2
18.0
12.0
DV 1
1
Unexposed
0.0
Pit floor
DUNDAS FORMATION
DANFORTH MEMBER
ROSEDALE MEMBER
THIN-BEDDED SHALE AND HARD LAYERS
MEDIUM-BEDDED SHALE
THIN-BEDDED LIMY AND SANDY ZONE
MIDDLE MIXED LAYER ZONE
MEDIUM-BEDDED LIMY AND SANDY ZONE
MEDIUM-BEDDED SHALE
LOWER MIXED LAYER ZONE
O. D. M. 3266

Figure 9—Toronto Brick Co. Ltd., Don Valley shale section.

Description of Don Valley shale section, Toronto Brick Co. Ltd. (figure 9.)

Unit		Thickness (*feet*)
Dundas Formation		
DV 7	SHALE: Medium grey, weathering to light grey; soft; thin-bedded with platy parting; moderate content of hard fossiliferous limy and sandy layers.	13.0
DV 6	SHALE: Green-grey, weathering to light grey; moderately soft; medium-bedded with platy parting; rare hard sandy lenses.	9.7
DV 5	SHALE, LIMESTONE, SANDSTONE: Grey and brown, weathering to light grey and buff; interlayered soft shale and hard limy and sandy beds; thin-bedded; hard layers comprise 50 percent of the unit.	6.5
DV 4	SHALE: Green-grey, weathering to light grey; moderately soft; medium-bedded with platy parting; moderate content of very thin limy and sandy hard layers.	11.5
DV 3	SHALE, LIMESTONE, SANDSTONE: Blue-grey to brown-grey hard fine-grained sandy lenses interlayered with medium-grained brown fossiliferous limy lenses and platy green-grey shale.	6.3
DV 2	SHALE: Green-grey, weathering to light grey; moderately soft; medium to thick-bedded; low content of thin-bedded, hard, limy sandstone lenses.	14.0
DV 1	SHALE: Green-grey, weathering to light grey; thin to medium-bedded with platy parting; moderate content of thin hard limy sandstone lenses.	12.0

TABLE 27 Mineral Analyses: Toronto Brick Company Limited, Don Valley

DUNDAS SHALE

(A = abundant; B = moderate; ND = not detected)

Sample	1	2	3	4	5	6	7	Composite
Height above floor (*feet*)	2.0–12.0	12.0–26.0	26.0–32.3	32.3–43.8	43.8–50.3	50.3–60.0	60.0–73.0	2.0–73.0
Non-clay minerals								
Quartz	35	23	32	27	26	31	26	27
Calcite	3	4	15	7	11	5	17	8
Dolomite	ND	2	4	<0.5	2	ND	<0.5	2
Soda-lime feldspar	2	1	8	2	2	2	2	3
Potash feldspar	<0.5	ND	ND	<0.5	<0.5	<0.5	ND	<0.5
Clay minerals								
Illite	A	A	A	A	A	A	B	A
Chlorite	B	A	B	B	B	B	B	B
Expanding minerals	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 28 Mineral Analyses: Toronto Brick Company Limited, Don Valley

INTERGLACIAL CLAYS

(B = moderate; C = minor)

Sample	8 Don Beds	9 Scarborough Beds
Height above floor (*feet*)	90.8–94.3	97.0–114.0
	(*percent*)	(*percent*)
Non-clay minerals		
Quartz	25	34
Calcite	7	3
Dolomite	3	4
Soda-lime feldspar	21	7
Potash feldspar	4	2
Amphibole	<1	<1
Clay minerals		
Illite	B	B
Chlorite	B	B
Expanding minerals	C	B*

*Montmorillonite

TABLE 29 Mineral Analyses: Toronto Brick Company Limited, Don Valley

GLACIAL VARVED CLAYS

(B = moderate; C = minor; D = trace; ND = not detected)

Sample	10	11	12	Composite
Height above floor (*feet*)	122.0–137.0	137.0–148.0	148.0–158.0	122.0–158.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	17	19	18	19
Calcite	28	27	32	30
Dolomite	3	4	4	5
Soda-lime feldspar	4	5	4	3
Potash feldspar	ND	1	<0.5	1
Amphibole	<1	<1	<1	1
Clay minerals:				
Illite	B	B	B	B
Chlorite	B	B	B	B
Expanding minerals	C	C	D	B

F-R-H Junior combined pug, de-airing extruders; the clay stream is cut by J. C. Steele wire-cutters.

Brick are hacked 3,000–3,300 per car and are preheated in a holding room to 100°F. Drying is accomplished in six single-track tunnel dryers; each tunnel is 140 feet long and holds 14 cars.

The brick are fired in two Harrop tunnel kilns, each 376 feet long. Each kiln holds 38 cars and is operated at the rate of 16 cars per day. The kilns are gas-fired, but light industrial oil is maintained as a standby. Flashing is accomplished in a special bleaching-reducing zone built into each kiln.

TABLE 30 Ceramic Tests: Toronto Brick Company Limited, Don Valley

SAMPLE 1: Dundas shale 2.0′–12.0′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	2.5
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5	1.7	3.7
Colour	light salmon	salmon-red	red-brown
Hardness	hard	hard	very hard
24-hour absorption (%)	12.2	9.5	1.3
5-hour boil absorption (%)	13.8	11.4	2.9
Specific gravity	1.96	2.05	2.14

REMARKS: Briquettes are slightly blistered and overfired at cone 03.

SAMPLE 2: Dundas shale 12.0′–26.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.3
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3	1.0	3.0
Colour	salmon	salmon	dark red-brown
Hardness	hard	hard	very hard
24-hour absorption (%)	11.2	9.4	0.6
5-hour boil absorption (%)	12.7	11.1	2.0
Specific gravity	2.00	2.06	1.94

REMARKS: Briquettes are blistered and overfired at cone 03.

SAMPLE 3: Dundas shale 26.0′–32.3′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.0
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5 (expansion)	1.0 (expansion)	3.6
Colour	light salmon	light salmon	dark brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)		15.0	3.8
5-hour boil absorption (%)		17.8	7.0
Specific gravity		1.83	2.02

REMARKS: Briquettes fired at cone 010 were chalky and weak; they crumbled after short exposure to the air. Briquettes fired to cone 03 are blistered and overfired.

SAMPLE 4: Dundas shale 32.3′–43.8′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	2.7
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.1	1.7	3.4
Colour	light salmon	salmon-red	dark brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	12.7	9.8	1.5
5-hour boil absorption (%)	14.4	12.2	3.4
Specific gravity	1.93	2.02	2.10

REMARKS: Briquettes are blistered and overfired at cone 03.

SAMPLE 5: Dundas shale 43.8′–50.3′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.2
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.7 expansion	0.7
Colour	tan	light salmon	yellow-brown
Hardness	soft	hard	very hard
24-hour absorption (%)		16.5	8.2
5-hour boil absorption (%)		18.7	12.2
Specific gravity		1.81	1.91

REMARKS: Briquettes fired at cone 010 disintegrated on exposure to the air due to slaking of limy particles from the hard layers in the section. Briquettes are blistered and overfired at cone 03.

SAMPLE 6: Dundas shale 50.3′–60.0′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	2.5
Pyrometric cone equivalent	5–6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	2.2	3.2
Colour	light salmon	salmon	dark red
Hardness	almost hard	hard	very hard
24-hour absorption (%)	11.8	7.9	1.2
5-hour boil absorption (%)	13.3	9.6	3.0
Specific gravity	1.98	2.12	2.13

REMARKS: Briquettes are blistered and overfired at cone 03.

TABLE 30 (*continued*)

SAMPLE 7: Dundas shale 60.0′–73.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.3
Pyrometric cone equivalent	5–6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	0.8
Colour	tan	salmon	yellow-brown
Hardness	soft	almost hard	very hard
24-hour absorption (%)		14.4	7.4
5-hour boil absorption (%)		16.7	10.8
Specific gravity		1.87	1.94

REMARKS: Briquettes fired to cone 010 were soft and chalky, and disintegrated on exposure to the air. At cone 03 the shale is slightly blistered and overfired.

SAMPLE 8: "Don Beds" clay 90.8′–94.3′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	4.3
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3 expansion	0.5 expansion	0.5
Colour	tan	pink-brown	pink-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	16.3	14.7	11.4
5-hour boil absorption (%)	17.6	17.5	15.9
Specific gravity	1.82	1.82	1.88

REMARKS: Yellow-white scum common on all fired briquettes.

SAMPLE 9: "Scarborough Beds" clay 97.0′–114.0′

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	5.5
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	3.5
Colour	light brown	pink-brown	red-brown
Hardness	soft	almost hard	very hard
24-hour absorption (%)	15.8	14.8	7.8
5-hour boil absorption (%)	17.5	16.9	9.0
Specific gravity	1.78	1.82	2.01

REMARKS: Some yellow scum on fired briquettes.

SAMPLE 10: Glacial clay 122.0′–137.0′

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	5.0
Pyrometric cone equivalent	2

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	0.4
Colour	tan	cream	buff
Hardness	almost hard	moderately soft	almost hard
24-hour absorption (%)	21.3	12.4	22.1
5-hour boil absorption (%)	22.0	23.4	24.2
Specific gravity	1.65	1.65	1.67

REMARKS: Slight blistering at cone 03.

SAMPLE 11: Glacial clay 137.0′–148.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.0
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3 expansion	0.5 expansion	0
Colour	tan	cream	buff
Hardness	moderately soft	moderately soft	moderately soft
24-hour absorption (%)	21.5	21.2	21.0
5-hour boil absorption (%)	22.4	22.8	24.5
Specific gravity	1.64	1.63	1.65

REMARKS: Makes an attractive briquette at cone 03.

SAMPLE 12: Glacial clay 148.0′–158.0′

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	5.0
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3	0.1	0.9
Colour	dark tan	cream-tan	buff
Hardness	moderately soft	moderately soft	moderately soft
24-hour absorption (%)	20.7	21.3	20.6
5-hour boil absorption (%)	21.7	24.6	24.8
Specific gravity	1.63	1.61	1.65

REMARKS: Fine white specking on some briquettes.

BAXTER 3926

Photo 17—Toronto Brick Company Limited; plant and quarry, 1958. (Photo by Les Baxter, Toronto.)

Smooth-faced brick are also produced by the dry-press process. Three Boyd heavy duty toggle-type machines, and two smaller Boyd machines are used. Dry-pressed brick are formed with a moisture content of 8 percent.

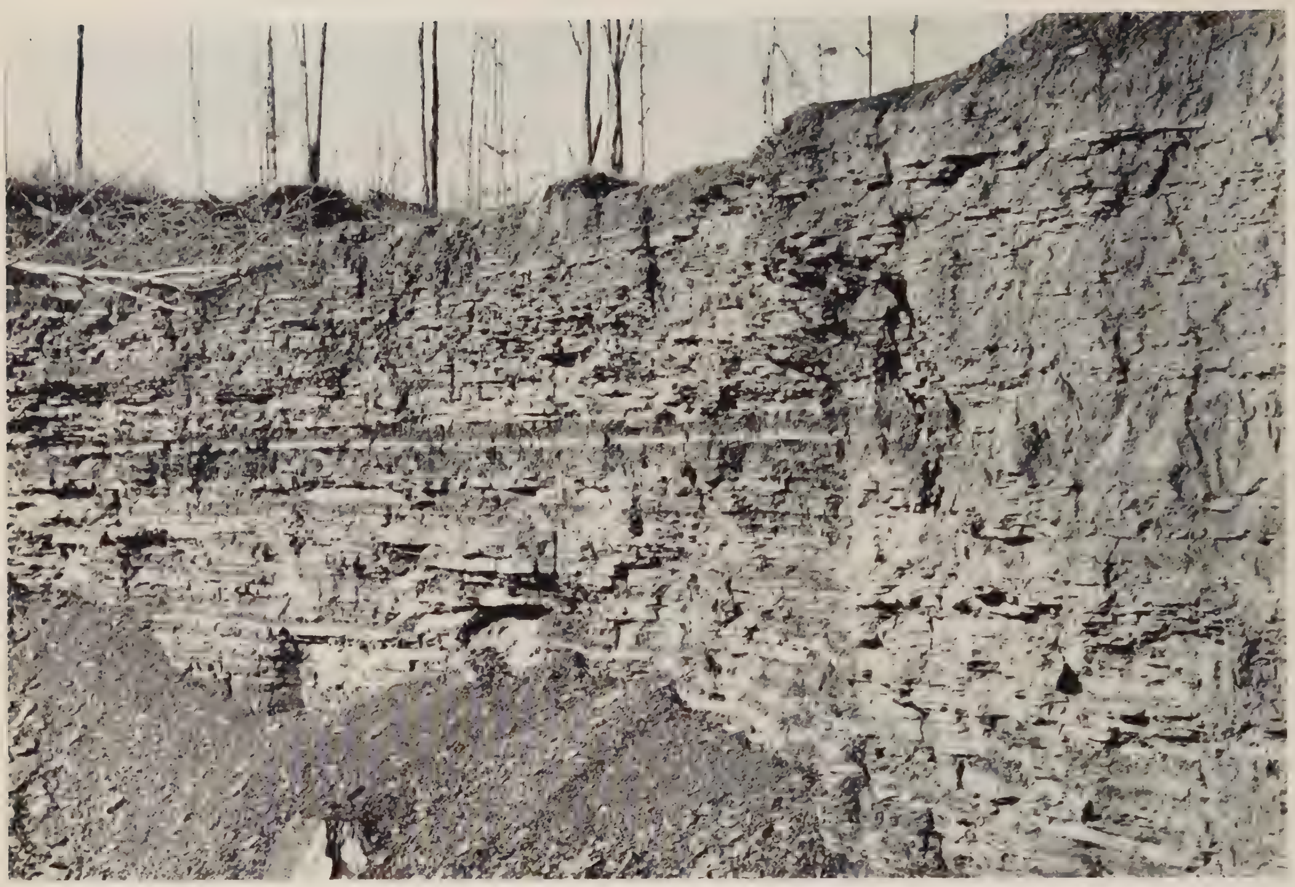
Dry-pressed red brick are used for glazing. After pressing, the brick are dried in two narrow-gauge track tunnel dryers. They are then sorted and transferred to the spray hood for glaze application. A belt conveyor carries them directly to a preheater hood, from which the brick are discharged at a temperature of 450°F. Preheating renders the ceramic glaze sufficiently hardened to permit gentle handling, and the brick are then hacked 1,100 to a car for firing. A semi-muffle type tunnel kiln 215 feet long accommodates 29 cars and produces glazed brick at the rate of 14 cars per day. Stove oil is used for fuel, and the peak firing temperature is 1850°F. Only the exposed brick surfaces are glazed. Using prepared frits, with suitable stains and oxides, glaze coatings of any colour can be applied. A special type textured glazed brick, with 15-20 percent of the brick body exposed on the face, has also been developed.

GEOLOGY

The quarry of the Toronto Brick Company Limited is cut into the northwest slope of the Don valley ½-mile north of Bloor Street on the west side of the Bayview Avenue extension. The floor of the quarry lies 40 feet below the valley floor. In the north face, 73 feet of Dundas shale, Rosedale (18 feet) and Danforth (55 feet) members, are exposed. Core drilling by the company has proven the continuation of the grey shales more than 300 feet below the quarry floor. The shale is said to have become progressively harder, the occurrence of hard limestone layers more frequent, and the ground shale less plastic as the depth increases. The Blue Mountain and Collingwood Formations are undoubtedly represented in the deeper shales.

Above the shale on the east side of the quarry are 3 feet of gravel which were deposited by a glacial stage known as the Illinoian more than 200,000 years ago (Prest, 1957, p. 444). Resting on the glacial gravel are stratified sands and clays deposited during the Sangamon interglacial stage. These include 21 feet of stratified sand and minor clay known as the Don Beds, containing fragments of shells and vegetation indicative of a warm climate. A subsequent interval of cooler climate is represented by 17 feet of clay known as the Scarborough Beds. The Wisconsin glacial stage is represented by 5 feet of till overlain by 39 feet of varved clay in the northeast part of the pit. The interglacial clays are described by Terasmae (1960).

The shale and Pleistocene sections are illustrated in figures 8 and 9. The sequence of sand, gravel, and clay overlying the shale is one of the most famous Pleistocene sections in the world. It is amply described by Coleman (1933, pp. 5–15). The results of chemical, mineralogical, and ceramic testing of chip samples of the shale and vertical channel samples of the clays are given in tables 25, 26, 27, 28, 29, and 30.



ODM7444

Photo 18–Queenston shale in the quarry of Diamond Clay Products Limited, Tansley.

Photo 19–Blocky medium-bedded Queenston shale.

ODM7445

Photo 20–Soft weathered Queenston shale.

ODM7446

Part III Queenston Shale

Shale of the Queenston Formation is a major raw material for 12 brick and tile plants in Ontario. The formation outcrops (Map 2131, see back pocket) along the base of the Niagara escarpment, forming the shoreline of Lake Ontario from the Niagara River to Hamilton. North of the lake, in Halton and Peel counties, the width of the outcrop belt reaches its maximum of about 12 miles, and it continues with diminishing width along the escarpment west of Collingwood, through Owen Sound, disappearing beneath Georgian Bay along the east side of the Bruce Peninsula. There is also a small outcrop of Queenston shale in Russell county, near Ottawa. The formation dips south or southwest at a low angle and passes beneath younger strata in the Niagara escarpment and southwestern Ontario. Good exposures of the shale can be seen along the southern reaches of the Credit River, Oakville and Bronte creeks, at the Lake Ontario end of the Niagara River, and at the base of the Niagara escarpment on various creeks between Niagara and Hamilton.

QUEENSTON FORMATION

The Queenston Formation is upper Ordovician in age, and it occupies a position at the top of the Ordovician system in Ontario. It gets its name from the type locality on the Niagara River near Queenston. Queenston shale rests upon Meaford shale, and is overlain by Whirlpool sandstone of Silurian age. The upper contact is a sharp stratigraphic break, with sandstone resting directly on typical red shale or in some places on a thin layer of soft green shale-mud. The lower contact with the Meaford Formation is gradational by the upward continuation of hard fossil-bearing sandy and limy layers 15–20 feet into the typical red and green Queenston shales. The contact is marked at the first red shale, and except for the Meaford fossils occurring in the gradational zone the Queenston Formation is practically barren of fossils. Features of the lower contact are well exposed in the Streetsville quarries of Canada Brick Limited and F. B. McFarren Limited. Bore-hole records from Halton, Wentworth, and Wellington counties show the Queenston Formation to be 440–500 feet thick, and to be thinning rapidly to the north (Caley 1940, p. 24; Sandford 1961, p. 15); 130 feet of Queenston shale is exposed in the quarry of Milton Brick Limited.

LITHOLOGY

The Queenston Formation consists predominantly of brick-red, thin- to thick-bedded, sandy and argillaceous shale. Caley (1940, p. 24) suggests that all but the lower few feet of the formation were laid down as terrestrial deposits on the edge of the retreating Meaford sea, and that "The red colour is generally ascribed to peculiar, and perhaps local, climatic conditions, which permitted extensive oxidation of the iron compounds present in the sediments while they were undergoing transportation or during or after deposition. Such oxidation is known to be extensively carried on under arid climatic conditions and with a much reduced or total absence of vegetation."

The formation is further described by Caley (1940, p. 23) as follows:

> The lower few feet of the formation may contain occasional greenish and reddish limestone and sandy layers, most of which enclose fossils of Richmond age. The shales are almost everywhere seamed by narrow, greenish bands disposed both parallel and (less frequently) at right angles to the bedding planes. The vertical seams appear to lie along small joint fissures; the horizontal ones along what may be zones of greater permeability; and the colour is probably due to a bleaching by percolating waters charged with organic acids in solution. At some localities the green colour is in the form of circular patches, imparting a mottled appearance to the shale.

Small oval or circular "eyes" of green shale frequently have centres consisting of calcite geodes or dark carbonaceous fragments.

The Queenston shale readily breaks down by normal weathering processes, and forms a fine, reddish, clay soil; this feature is especially conspicuous below the Niagara escarpment from Niagara River to the vicinity of Hamilton. Weathered Queenston shale is exposed in the quarries of St. Catharines Brick and Tile Company Limited and Grimsby Tile Limited; also in eroding hills near Waterdown and Terra Cotta.

CERAMIC PROPERTIES

Unweathered Queenston shale has a fairly short firing range and a light-red fired colour. The depth of colour varies with the proportion of green shale; the latter has a higher content of lime and by itself is buff-burning. The green shale is also somewhat harder and less plastic. Some companies practise selective quarrying or sorting to emphasize either a red or buff fired colour. Weathered Queenston shale has a longer firing range and a deeper-red fired colour.

Table 31 Ceramic Properties of Queenston Shale

UNWEATHERED SHALE			
Water of plasticity (*percent*)	17		
Lineal drying shrinkage (*percent*)	3.2		
Pyrometric cone equivalent	4		
	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	0.9
24-hour cold water absorption (%)	13.4	12.3	8.5
5-hour boil absorption (%)	14.2	15.2	11.5
WEATHERED SHALE			
Water of plasticity (*percent*)	20		
Lineal drying shrinkage (*percent*)	3.8		
Pyrometric cone equivalent	5		
	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5	2.1	3.5
24-hour cold water absorption (%)	12.1	9.0	4.0
5-hour boil absorption (%)	13.5	11.0	5.5

The average properties of unweathered Queenston shale from 10 brick quarries in the Toronto-Hamilton area are compared in Table 31 with the average properties of deeply-weathered shale from 4 quarries.

Plasticity of the unweathered shale is barely adequate for modern extrusion equipment. Experimentation towards improving its workability is discussed by Bell (1962), Naish (1953), and Corbett and Runnalls (1949); natural weathering and fine grinding result in some improvement.

CHEMICAL COMPOSITION

Only minor variation in the chemical composition of the Queenston shale is noted from place to place. Lime (CaO) is the most variable constituent, showing a range of 3.2–17.7 percent in forty-six samples taken from fourteen quarries. Iron (Fe_2O_3) has a range of 4.5–7.4 percent in the same samples. It is the content of lime, therefore, that largely determines the colour and porosity of the fired ware. Lime content appears to be directly proportional to the frequency of green shale beds.

Table 32 Chemical Composition of Queenston Shale

	Unweathered shale	Weathered shale
	(*percent*)	(*percent*)
SiO_2	51.28	56.28
Al_2O_3	13.9	16.0
Fe_2O_3	6.15	6.77
CaO	9.00	4.74
MgO	3.48	2.55
Na_2O	0.58	0.70
K_2O	3.60	3.93
TiO_2	0.72	0.85
CO_2	7.29	3.81
H_2O+	2.73	3.21
H_2O-	0.80	0.92
SO_3	0.26	0.33
TOTALS	99.8	100.1

The average composition of unweathered Queenston shale from nine quarries in the Toronto-Hamilton area is shown in Table 32. The beneficial effect of leaching and weathering is particularly apparent in the reduction of the lime content in a sample of deeply weathered shale from a quarry in the Niagara peninsula.

MINERAL COMPOSITION

Queenston shale consists of 60 percent clay minerals and 40 percent non-clay minerals. X-ray diffraction studies on 45 channel samples from thirteen quarries indicate that illite is the most

Table 33 Non-clay Minerals in Queenston Shale

	Average of 45 samples	Range
	(*percent*)	(*percent*)
Quartz	26	18–34
Calcite	11	2–30
Dolomite	1.8	0–8
Soda-lime feldspar	1.3	0–7
Potash feldspar	trace	0–2

abundant clay mineral and that chlorite occurs in moderate amount. Vermiculite is sometimes present in trace amounts. The average composition of the non-clay fraction, as determined by x-ray diffraction methods by the Laboratory Branch, Ontario Department of Mines, is given in Table 33.

CHEMICAL AND MINERAL VARIATIONS

Because of its lithological uniformity and lack of fossils the Queenston Formation is not subdivided. Except for a few Meaford-type fossils in hard limy layers near the base there is little obvious variation throughout the formation. In several exposures located near the stratigraphic centre of the formation, green bands are more common and diffuse, resulting in a somewhat harder variegated zone; but because the green colouration is probably a secondary feature and of local extent, the zone is not recognized as a distinct unit.

Small, but progressive, chemical and mineralogical variations are revealed by detailed analytical work. The formation becomes progressively less siliceous and more dolomitic from the bottom to the top. The content of iron is constant throughout, but lime varies irregularly, strengthening the view that the green shales are an alteration product formed in the more porous shale beds by carbonate-bearing groundwaters.

The chemical and mineralogical analyses in tables 34 and 35 illustrate the progressive variations in the formation. The analytical work was performed by the Laboratory Branch, Ontario Department of Mines, on composites of vertical channel samples from six active shale quarries. They are presented in relative order from west to east across the Queenston outcrop belt, and hence represent the formation at various stratigraphic levels from top to bottom. An anomalous zone near the centre, as exposed in the quarries of Natco Clay Products Limited and Diamond Clay Products Limited, is typical of the harder variegated shales formed by the introduction of lime.

TABLE 34 Chemical Variations in the Queenston Formation
(quantities in percent)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	CO_2	H_2O+	SO_3
TOP OF FORMATION											
Milton Brick Ltd., Milton	50.91	14.9	6.53	7.41	4.40	0.36	4.02	0.73	6.67	2.93	0.27
National Sewer Pipe Ltd., Waterdown	52.02	14.5	6.57	6.81	3.75	0.32	4.12	0.76	5.88	2.91	0.28
Natco Clay Products Ltd., Aldershot	49.67	14.3	6.27	10.2	3.15	0.58	3.64	0.76	8.64	2.42	0.28
Diamond Clay Products Ltd., Tansley	45.10	11.9	4.57	14.3	2.63	0.81	2.99	0.67	12.47	2.13	0.32
Brampton Brick Ltd., Brampton	55.00	14.0	6.17	7.25	3.23	0.90	3.23	0.72	5.81	2.64	0.31
McFarren Brick Ltd., Streetsville	55.97	13.4	6.58	6.34	2.68	0.76	3.25	0.80	5.24	2.53	0.20
BOTTOM OF FORMATION											

TABLE 35 Mineral Variations in the Queenston Formation
(A = abundant; B = moderate; D = trace; ND = not detected)

	Quartz	Calcite	Dolomite	Na–Ca feldspar	K feldspar	Illite	Chlorite	Vermiculite
TOP OF FORMATION								
Milton Brick Ltd., Milton	24	10	4	<0.5	<0.5	A	B	ND
National Sewer Pipe Ltd., Waterdown	28	10	2	<0.5	ND	A	B	ND
Natco Clay Products Ltd., Aldershot	24	15	2	1	ND	A	B	ND
Diamond Clay Products Ltd., Tansley	25	24	4	3	<0.5	A	B	ND
Brampton Brick Ltd., Brampton	27	11	<0.5	3	ND	A	B	ND
McFarren Brick Ltd., Streetsville	27	10	ND	3	<0.5	A	B	D
BOTTOM OF FORMATION								

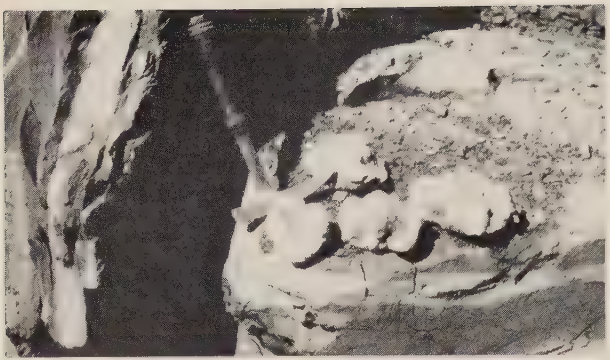


Photo 21–Botryoidal gypsum nodules from the Queenston shale.

GYPSUM

Gypsum is an undesirable constituent that is present in trace amounts throughout the Queenston Formation. It occurs either in discreet units, frequently as salmon-pink or buff-coloured nodules less than 1-inch in diameter, but also in botryoidal masses up to 1-foot or more in size, or in tabular sheets ⅛-inch thick. The nodular forms appear to be concretionary; they have radiating acicular structures. The tabular sheets occupy open bedding-planes or fractures; they have a cross-fibre texture oriented at a large angle to the walls. Solution cavities in the shale appear in many cases to have once been gypsum-filled. Although gypsum is found in almost all exposures of Queenston shale, it commonly shows preference for certain zones of limited thickness. Selective quarrying and hand-sorting is sometimes effective in reducing the content of gypsum in the feed to the plant, but the addition of barium carbonate to render the remainder insoluble is essential for complete efflorescence control.

Producers Using Queenston Shale

BRAMPTON BRICK LIMITED

Brampton Brick Limited is located on Highway no. 10 on the northern outskirts of Brampton. The pit and plant are in lot 10, concession I E, Chinguacousy township, Peel county. Brick have been made on this site for nearly 80 years. Early references to brick-making by this company are given by Baker (1906, p. 89), Keele (1924, p. 22), and Montgomery (1930, p. 148).

Plant

The plant has recently been largely rebuilt and is very modern in design. It is rated at a capacity of 24 million brick annually, all made by the extruded, wire-cut, method. Prior to 1963 brick were made exclusively by the dry-press method. The operation employs a total of 47 men.

Five feet of sandy loam overburden is stripped by bulldozer, and the underlying few feet of soft shale is scraped into piles for subsequent shovel loading. The unweathered shale is worked in two 18-foot benches by drilling and blasting. A ½-yard Link Belt diesel shovel loads a 6-yard Goering dump truck for the short haul to the primary crusher located on the quarry floor. The 4-inch discharge from the 24-inch Meco toothed double-roll crusher is conveyed from the quarry by covered belt to a 6,000-ton storage building. Soft surface shale and hard unweathered shale are kept separate by means of an overhead travelling conveyor. A small amount of water added by spraying is effective in controlling dust in the storage area and improving the workability in the extruder. Shale is reclaimed from storage by a Hough Payloader and conveyed to the main building by belt. Limestone and other additives are proportioned onto the belt by separate bins and feeders. Batching and grinding is completely interlocked and controlled from a centrally located Westinghouse control panel. Grinding is accomplished by a 9-foot Clearfield drypan in closed circuit with four 4-foot by 8-foot heated vibrating screens. The 16-mesh shale is raised to two small storage bins. It is conveyed from storage to the pugging section of a Bonnot extruder. Brick are extruded at the rate of 13,000 per hour under a vacuum of 27 inches. They are cut by a J. C. Steele cutter and are hacked on dryer cars, 5,300 per car. Drying is accomplished in a 4-track tunnel dryer that holds 7 cars on each track. The tunnels are gas-fired to 400°F at the hot end. Four cars are pulled every 4 hours.

There are 5 rectangular downdraft kilns, each 80 feet long and capable of holding about 175,000 brick. Brick are set in the kilns in cubes using Clarke fork-lift trucks. The firing schedule takes 6 days; the fuel is natural gas. Peak temperatures are in the 1900°–1950°F range.

Finished brick are stocked in the yard and shipped by truck in 500-brick cubes.

TABLE 36 Ceramic Tests: Brampton Brick Limited

SAMPLE 1: 0.0′–10.7′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.7
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3 (expansion)	0.4
Colour	salmon	salmon-red	brown
Hardness	almost hard	hard	hard
24-hour absorption (%)	11.6	11.4	10.3
5-hour boil absorption (%)	13.3	14.0	13.5
Specific gravity	1.93	1.91	1.91

REMARKS: Fired briquettes have a trace of white scum. At cone 03 the briquettes are slightly blistered and overfired.

SAMPLE 2: 10.7′–14.7′

Water of plasticity (*percent*)	15
Lineal drying shrinkage (*percent*)	2.3
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.3	1.4	1.4
Colour	salmon-brown	pink-brown	light brown
Hardness	almost hard	almost hard	almost hard
24-hour absorption (%)	15.2	14.7	13.7
5-hour boil absorption (%)	17.1	17.9	17.6
Specific gravity	1.84	1.80	1.80

REMARKS: Trace of scum on fired briquettes.

SAMPLE 3: 14.7′–29.2′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.8
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0	0.3	0.3
Colour	salmon	salmon-red	brown
Hardness	almost hard	almost hard	hard
24-hour absorption (%)	12.4	12.0	10.7
5-hour boil absorption (%)	14.0	14.5	13.7
Specific gravity	1.91	1.90	1.91

REMARKS: Briquettes are slightly blistered at cone 03.

SAMPLE 4: 29.2′–34.0′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	3.0
Pyrometric cone equivalent	4–5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.5	1.0	1.0
Colour	salmon	salmon-red	light brown
Hardness	almost hard	almost hard	hard
24-hour absorption (%)	14.3	14.1	12.8
5-hour boil absorption (%)	16.4	17.4	16.6
Specific gravity	1.85	1.81	1.82

REMARKS: Briquettes are slightly blistered at cones 06 and 03.

SAMPLE 5: 34.0′–42.5′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	3.5
Pyrometric cone equivalent	4–5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3 (expansion)	0.3 (expansion)	0.2
Colour	salmon	salmon-red	brown
Hardness	almost hard	almost hard	hard
24-hour absorption (%)	12.1	11.4	9.4
5-hour boil absorption (%)	13.7	14.0	12.4
Specific gravity	1.92	1.92	1.93

REMARKS: Briquettes are slightly blistered at cone 03.

SAMPLE 6: 42.5′–47.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	3.4
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3	0.3
Colour	salmon	salmon-red	red-brown
Hardness	hard	very hard	very hard
24-hour absorption (%)	11.6	10.4	4.9
5-hour boil absorption (%)	13.1	12.8	7.0
Specific gravity	1.94	1.96	2.13

REMARKS: Briquettes are slightly warped and overfired at cone 03.

GEOLOGY

A 70-foot section of Queenston shale is exposed in the quarry, but only the upper 47 feet is worked. The lower 23 feet can be seen in a large sump at the south end of the pit. The entire section is illustrated in figure 10. The results of chemical, mineralogical, and ceramic testing are given in the accompanying tables.

TABLE 37 Chemical Analyses: Brampton Brick Limited

Sample	1	2	3	4	5	6	Composite
Height above floor (*feet*)	0.0–10.7	10.7–14.7	14.7–29.2	29.2–34.0	34.0–42.5	42.5–47.0	0.0–47.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2							55.00
Al_2O_3							14.0
Fe_2O_3	6.42	4.67	6.24	5.48	5.98	7.08	6.17
CaO	6.78	9.63	6.65	8.08	5.51	5.53	7.25
MgO							3.23
Na_2O							0.90
K_2O							3.23
TiO_2							0.72
CO_2							5.81
H_2O+							2.64
H_2O-							0.69
SO_3							0.31
TOTAL							100.0
Loss on ignition	9.50	11.35	9.44	10.34	8.56	8.50	9.12
Soluble salts	0.34	0.54	0.46	0.33	0.42	0.64	

TABLE 38 Mineral Analyses: Brampton Brick Limited
(A = abundant; B = moderate; D = trace; ND = none detected)

Sample	1	2	3	4	5	6	Composite
Height above floor (*feet*)	0.0–10.7	10.7–14.7	14.7–29.2	29.2–34.0	34.0–42.5	42.5–47.0	0.0–47.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals							
Quartz	29	30	22	31	30	27	27
Calcite	5	15	10	12	7	6	11
Dolomite	ND	ND	3	3	ND	<0.5	<0.5
Soda-lime feldspar	<0.5	4	3	3	5	2	3
Potash feldspar	ND	ND	ND	ND	<0.5	ND	ND
Clay minerals							
Illite	A	A	A	A	A	A	A
Chlorite	B	B	B	B	B	B	B
Expanding minerals	ND	ND	ND	ND	D*	D*	ND

*Vermiculite.

Description of quarry section, Brampton Brick Ltd. (figure 10.)

Unit		Thickness (*feet*)
	OVERBURDEN: Yellow-brown silty clay loam with a moderate stone content.	4–6
B 7	SHALE: Uniformly red; soft, crumbly; weathered.	4.5
B 6	SHALE: Red with 20 percent green mottled beds; soft to moderately hard (green beds hardest); very thin-bedded; some rusty weathering.	8.5
B 5	SHALE: Mottled red and green; soft (red) to hard (green); thin-bedded with platy parting.	4.8
B 4	SHALE: Red, weathering buff to brown; moderately soft; thin to very thin-bedded; nodular weathering; rusty joint planes; less than 5 percent green beds; some intrastratal folding.	14.5
B 3	SHALE: Red, green, and mottled; soft to hard; thin to medium-bedded; green beds usually hard and compact, sometimes soft and fissile; 40 percent green shale.	4.0
B 2	SHALE: Red with 15 percent green mottled beds; moderately hard; laminated to very thin-bedded; occasional thin gypsum plates and small nodular gypsum concretions.	10.7
B 1	SHALE: Red with 10 percent green mottled beds; moderately hard; thin to very thin-bedded; hard green beds or lenses uniformly distributed	23.0

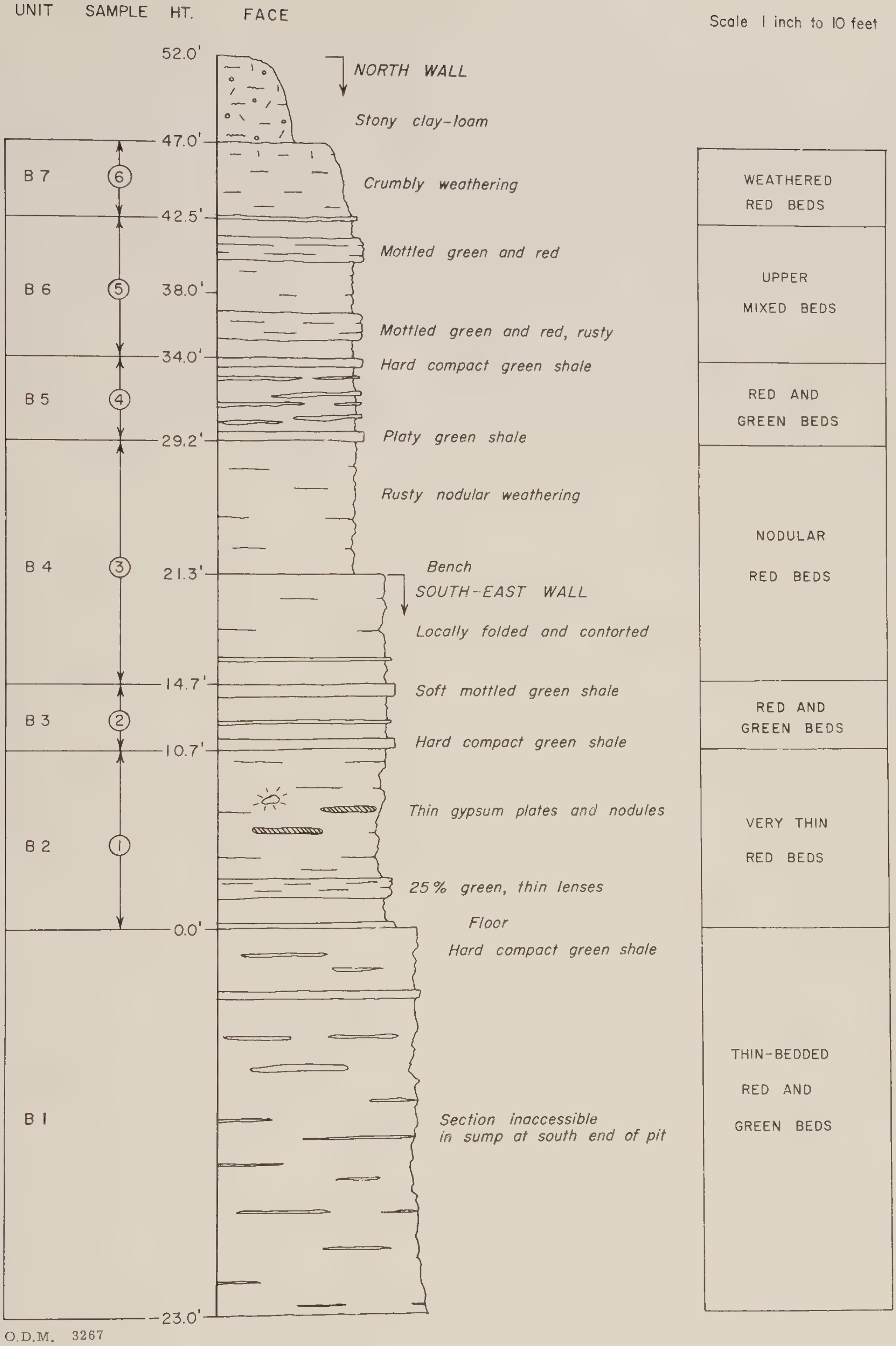

UNIT
SAMPLE
HT.
FACE
Scale 1 inch to 10 feet
52.0'
NORTH WALL
Stony clay-loam
47.0'
B 7
⑥
Crumbly weathering
WEATHERED RED BEDS
42.5'
Mottled green and red
B 6
⑤
38.0'
UPPER MIXED BEDS
Mottled green and red, rusty
34.0'
Hard compact green shale
B 5
④
RED AND GREEN BEDS
29.2'
Platy green shale
Rusty nodular weathering
B 4
③
21.3'
Bench
SOUTH-EAST WALL
NODULAR RED BEDS
Locally folded and contorted
14.7'
Soft mottled green shale
B 3
②
RED AND GREEN BEDS
10.7'
Hard compact green shale
Thin gypsum plates and nodules
B 2
①
VERY THIN RED BEDS
25% green, thin lenses
0.0'
Floor
Hard compact green shale
B 1
THIN-BEDDED RED AND GREEN BEDS
Section inaccessible in sump at south end of pit
23.0'
O.D.M. 3267

Figure 10–Brampton Brick Ltd., quarry section.

CANBRIL-1

Photo 22–Canada Brick (Streetsville) Limited; plant 1960. (Photo courtesy Canada Brick Ltd.)

CANADA BRICK LIMITED

The Streetsville plant of Canada Brick Limited commenced operations in March 1956. Both the quarry and plant are located on the northwest limits of Streetsville in lot 6, concession V W.H.S. Toronto township, Peel county.

Plant

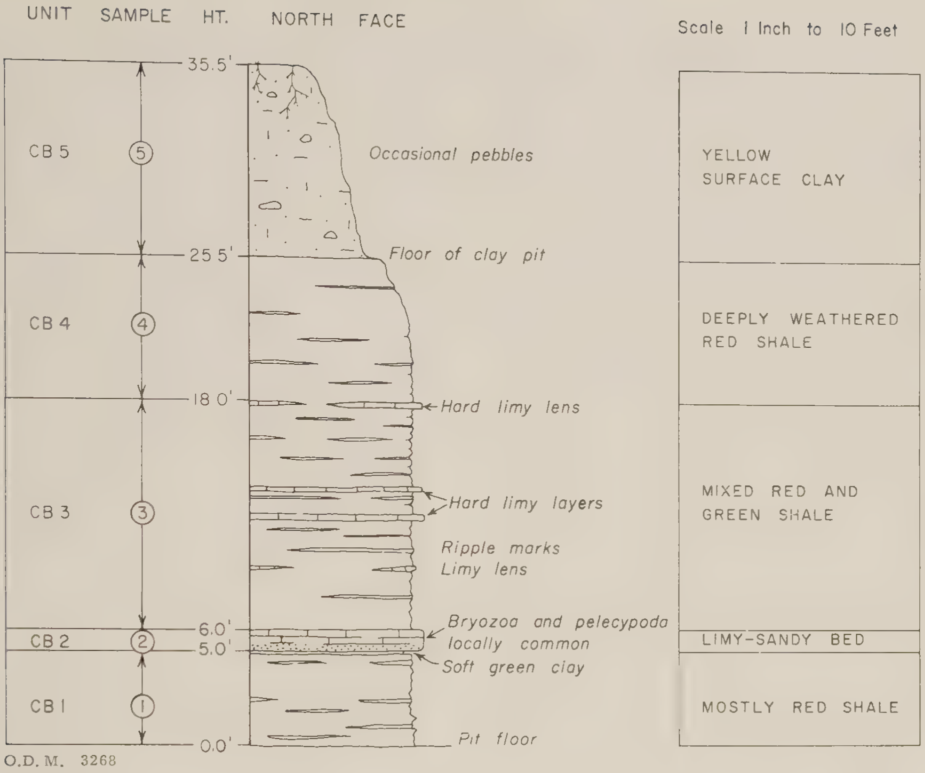
The plant is one of the largest in Ontario, producing over 60 million brick annually. Although 90 percent of the production is Ontario size, American and Modular brick are also made. A full range of colours and textures is available. The operation employs 95 men on a year-round basis.

Stripping the surface soil and sod is accomplished by scraper-type earth movers. A 3-yard Link Belt diesel shovel rips shale from the face without blasting and loads a 22-ton Euclid for the 1,000-foot haul to the plant. Clay is removed by a 1½-yard Northwest shovel, loading a 14-ton Euclid truck. The shale is received in a hopper at the plant and is delivered by plate feeder to a 48-inch conveyor belt. Green shale and hard limy layers are manually sorted from the belt and stockpiled in the yard by conveyor. The red shale is crushed in a Williams hammermill. Plus 8-mesh shale is scalped by a bank of four heated, vibrating screens, and is stockpiled outside. The undersize passes to two American 7-foot diameter rim-discharge drypans, each in closed circuit with a bank of 6 vibrating, heated, Link Belt 16-mesh screens. The plus 8-mesh shale scalped by the first set of screens is fed to the drypans at a rate sufficient only to maintain them at capacity load. Ground shale is stored in 5 corrugated steel silos, each of 500 tons capacity. Clay is dried in a gas-fired rotary dryer and is processed separately in the grinding and screening circuit. The principal additives, barium carbonate and manganese dioxide, are stored in two 30-ton bins.

Blending of the materials for the brick feed is accomplished by feeders beneath the storage bins. The feed is dry-mixed in an auger-type machine. Two brick-forming circuits use J. C. Steele equipment entirely. Each circuit consists of double pugging, deairing, auger extrusion, and #18 cutters, and is capable of producing 18,000 brick per hour. Normal texturing can be applied in either circuit, and both are equipped for sand-facing. Sixteen hackers are necessary to handle both circuits. Brick are hacked 3,120 per car and are stocked in a large "green brick" storage area maintained at 70°F.

Three waste-heat tunnel driers are 2, 2, and 3 tracks wide respectively. Four tracks hold 14 cars each; three hold 17 cars each. Drying temperature ranges from 100°F at the start to 400°F at the hot end, and drying time is 35 hours. There are 3 gas-fired (with oil stand-by) tunnel kilns. Two are 300-foot Harrop kilns with capacities of 30 cars each; one is a 350-foot kiln which holds 34 cars. Normal firing temperatures are 1850°F (red brick) to 1920°F (buff brick) for a 72-minute push. The addition of a fourth tunnel kiln and drier is expected to increase the production by 40 percent in 1966.

Brick are stored in the yard in 500-brick cubes. Shipments are made by truck and rail.


UNIT
SAMPLE
HT.
NORTH FACE
Scale 1 Inch to 10 Feet
35.5'
CB 5
5
Occasional pebbles
YELLOW SURFACE CLAY
25.5'
Floor of clay pit
CB 4
4
DEEPLY WEATHERED RED SHALE
18.0'
Hard limy lens
CB 3
3
Hard limy layers
Ripple marks
Limy lens
MIXED RED AND GREEN SHALE
6.0'
CB 2
2
5.0'
Bryozoa and pelecypoda locally common
Soft green clay
LIMY-SANDY BED
CB 1
1
MOSTLY RED SHALE
0.0'
Pit floor
O.D.M. 3268

Unit		Thickness (feet)
CB 5	CLAY: Medium grey, weathering to grey-yellow; sandy, moderately stony; unstratified; subrounded pebbles of limestone and granite to 2-inch, averaging $\frac{1}{2}$-inch; occasional fragments of red shale; minor roots near surface.	10.0
CB 4	SHALE: Red with minor green lenses; soft and crumbly due to weathering; thin to very thin-bedded; minor rusty weathering; some local folding.	7.5
CB 3	SHALE: Red with green lenses moderately common; moderately hard; laminated to very thin-bedded; several hard limy beds containing ripple marks and fossils.	12.0
CB 2	LIMESTONE: Grey-green, weathering to yellow-grey; very hard; thin to very thin-bedded; fine grained; sandy with shaly partings.	1.0
CB 1	SHALE: Red with occasional green lenses; moderately soft; laminated bedding.	5.0

Figure 11—Canada Brick Ltd., quarry section.

TABLE 39 Chemical Analyses: Canada Brick Limited

Sample	1	2	3	4	Shale composite	5
Height above floor (*feet*)	0.0–5.0	5.0–6.0	6.0–18.0	18.0–25.5	0.0–25.5	25.5–35.5
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2					55.11	45.74
Al_2O_3					14.1	10.9
Fe_2O_3	7.42	2.81	6.18	6.96	6.77	4.57
CaO	3.20	23.3	6.40	5.17	6.22	16.5
MgO					2.85	2.70
Na_2O					0.73	1.08
K_2O					3.43	2.35
TiO_2					0.75	0.62
CO_2					4.79	12.26
H_2O+					3.06	1.95
H_2O-					0.68	1.04
SO_3					0.31	0.31
TOTALS					98.8	100.0
Loss on ignition	6.67	18.46	9.18	8.66	8.42	15.77
Soluble salts	0.58	0.30	0.38	0.36		

TABLE 40 Mineral Analyses: Canada Brick Limited
(A = abundant; B = moderate; C = minor; ND = none detected)

Sample	1	2	3	4	Shale composite	5
Height above floor (*feet*)	0.0–5.0	5.0–6.0	6.0–18.0	18.0–25.5	0.0–25.5	25.5–35.5
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals						
Quartz	34	34	28	24	33	28
Calcite	4	43	11	5	10	28
Dolomite	ND	ND	<0.5	ND	ND	4
Soda-lime feldspar	1	2	3	<0.5	3	8
Potash feldspar	2	<0.5	ND	ND	<0.5	<0.5
Clay minerals						
Illite	A	C	A	A	A	B
Chlorite	B	C	B	B	B	C
Expanding minerals	ND	ND	ND	ND	ND	C*

*Vermiculite.

TABLE 41 Ceramic Tests: Canada Brick Limited

SAMPLE 1: Shale 0.0′–5.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	3.8
Pyrometric cone equivalent	5

	Cones 010 (1660°F)	 06 (1840°F)	 03 (1980°F)
Lineal firing shrinkage (%)	0.3	2.1	3.3
Colour	salmon	salmon-red	dark red
Hardness	hard	very hard	very hard
24-hour absorption (%)	11.2	8.2	2.8
5-hour boil absorption (%)	13.1	10.1	4.6
Specific gravity	1.97	2.08	2.15

REMARKS: Fired briquettes have a trace of scum on the edges, and are blistered and overfired at cone 03.

SAMPLE 3: Shale 6.0′–18.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	3.5
Pyrometric cone equivalent	5

	Cones 010 (1660°F)	 06 (1840°F)	 03 (1980°F)
Lineal firing shrinkage (%)	0	0	0.5
Colour	salmon	salmon-pink	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	14.2	13.0	7.6
5-hour boil absorption (%)	15.9	15.8	11.2
Specific gravity	1.87	1.87	1.98

REMARKS: Briquettes are slightly blistered and overfired at cone 03.

SAMPLE 4: Shale 18.0′–25.5′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	3.9
Pyrometric cone equivalent	5

	Cones 010 (1660°F)	 06 (1840°F)	 03 (1980°F)
Lineal firing shrinkage (%)	0.7	1.7	2.6
Colour	salmon	salmon-red	brown-red
Hardness	hard	very hard	very hard
24-hour absorption (%)	11.7	9.2	4.6
5-hour boil absorption (%)	13.1	11.4	7.1
Specific gravity	1.94	2.02	2.12

REMARKS: Briquettes are undeformed but slightly overfired at cone 03.

SAMPLE 5: Clay 25.5′–35.5′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	3.7
Pyrometric cone equivalent	1

	Cones 010 (1660°F)	 06 (1840°F)	 03 (1980°F)
Lineal firing shrinkage (%)	0.7	0.5	1.2
Colour	light brown	tan	buff
Hardness	almost hard	hard	very hard
24-hour absorption (%)		20.1	14.0
5-hour boil absorption (%)		22.9	17.5
Specific gravity		1.74	1.80

REMARKS: Briquettes fired at cone 010 disintegrated due to the slaking of burned limestone fragments. At cone 03 the buff briquettes are marked by a brown specking.

GEOLOGY

The shale quarry occupies a large area northwest of the plant. The lowermost beds of the Queenston Formation are represented in the 25-foot section exposed. Hard limy green beds in the quarry floor contain ripple marks and fossils; bryozoans and pelecypods typical of the underlying Meaford Formation are locally common. The lower strata appear to have been deposited from shallow marine waters, probably representing the waning stages of the Meaford sea. Succeeding red shale beds, in which fossils are scarce or absent, are believed to have been deposited subaerially (Caley, 1940, p. 24).

A 10-foot section of yellow-grey till containing a few stones is exposed in a pit west of the plant. The clay was deposited by the Wisconsin ice sheet towards the close of the Pleistocene epoch; it forms a sheet of variable thickness above the Queenston shale.

A section through the clay pit and the north face of the shale quarry is illustrated and described in figure 11. The results of chemical, mineralogical, and ceramic testing are given in tables 39, 40, 41.

CANADIAN PRESSED BRICK COMPANY, LIMITED

A plant located at the base of the escarpment on Kenilworth Drive in the southeast part of Hamilton has been owned by the Wright family since 1923. In the early 1950's a new approach to Hamilton mountain was built for Highway no. 55. across the company's shale property. By agreement with the city, a large amount of shale excavated for the highway was stockpiled for the company's use. Early references to brick-making at this site are given by Keele (1924, pp. 22, 97–98) and Montgomery (1930, p. 161).

Plant

Six million brick are produced annually. They are mostly Ontario size but Norman, Roman, and Modular brick are also made. Formerly a dry-press plant exclusively, the production is now mainly stiff-mud brick. Twenty-five men are employed the year-round.

Trucking of the shale to the plant is usually by contract, and a 5,000-yard stockpile is built-up at a time. A ¾-yard Trojan Loadster reclaims the shale and feeds it by way of an inclined chute to one of two parallel grinding and screening circuits. Both circuits are used at times of peak demand or when handling different feed materials. Each consists of a 9-foot Berg drypan in closed circuit with a 4-foot by 8-foot vibrating Leahy screen. A wooden storage bin holds sufficient 8-mesh shale for production of 7,500 brick. The shale is delivered by disc feeder to the pug mill or dry-press machine. The bulk of production is by the stiff-mud process, using an E. M. Freese combined pug and auger extruder without de-airing. Brick are made at the rate of 4,000 per hour and are cut by a 14-brick Chambers cutter. The dry press is a Berg 4-brick machine capable of producing 2,000 brick per hour. Stiff-mud brick are hacked 500 per car for drying, while dry-pressed brick are taken directly to the kiln.

Eight tunnel dryers can accommodate 15 cars on each track. They are heated with soft coal to a peak temperature above 300°F. Drying time is 48 hours. There are 4 rectangular downdraft kilns, each about 60 feet long and having a capacity of 120,000 brick. They are fired by soft coal to 1800°–1850°F.

Finished brick are stacked in the yard and shipped by truck in cubes of 500.

GEOLOGY

Formerly, the quarry of Canadian Pressed Brick Company Limited was opened in Queenston shale in the north slope of Hamilton mountain. Agreement with the city for road right-of-way was conditional on the city providing excavated shale as a stockpile for future plant operations. The main stockpile is maintained 500 yards away from the plant. The shale is typical of the Queenston Formation, consisting of moderately soft red shale with about 5 percent hard green shale. It has benefited by natural weathering. The results of chemical, mineralogical, and ceramic testing of a small bulk sample taken from the plant stockpile are given in tables 42, 43, and 44.

TABLE 42 Partial Chemical Analysis: Canadian Pressed Brick Company, Limited

	bulk sample (*percent*)
Fe_2O_3	6.87
CaO	5.25
Loss on ignition	8.70
Soluble salts	0.52

TABLE 43 Mineral Analysis: Canadian Pressed Brick Company, Limited
(A = abundant; C = minor; ND = not detected)

	bulk sample (*percent*)
Non-clay minerals:	
Quartz	29
Calcite	5
Dolomite	2
Soda-lime feldspar	<0.5
Potash feldspar	<0.5
Clay minerals:	
Illite	A
Chlorite	C
Expanding minerals	ND

TABLE 44 Ceramic Tests: Canadian Pressed Brick Company, Limited

SAMPLE: (bulk sample from stockpile)

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	4.0
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage	0.3	1.0	2.0
Colour	salmon	salmon-red	red-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	11.3	9.3	5.6
5-hour boil absorption (%)	12.7	11.4	8.1
Specific gravity	1.96	2.00	2.06

CONTINENTAL BRICK AND TILE COMPANY

A small plant on the southwest side of Shallow Lake, some 8 miles northwest of Owen Sound, has produced intermittently since it was built about 1900. Production was renewed in the spring of 1961. The plant is located in lot 7, concession VII, Keppel township, Grey county. The early history of brickmaking at this location is given by Montgomery (1930, p. 120).

Plant

The production is about 800,000 tile in sizes of 4 to 10 inches during the 6- or 7-month working season. Brick are occasionally produced. Five men are employed.

The raw materials arrive at the plant by truck and are stocked in a covered storage area. The Dundas and Queenston shales are batched by an Allis-Chalmers front-end loader and delivered to a Frost 9-foot diameter drypan by way of an inclined chute. Discharge from the drypan is elevated to a 12-mesh 4-foot by 9-foot vibrating screen. Oversize is returned to the pan, and the undersize is stored in a steel bin of 15,000-brick equivalent capacity. A single-shaft pug mill is fed by belt from storage, and a Plymouth Special combined pug and auger extruder extrudes a single stream with de-airing at the rate of 2,000 tile per hour. The clay stream is cut by a Steele No. 18 cutter. Drive for all equipment is provided by a 145 hp. Allis-Chalmers diesel motor. The tile are hacked on wood pallets, 120 per pallet, for shed drying.

Natural drying is accomplished in 4 to 10 days in an open shed 200 by 30 feet in area. There are two beehive kilns of 18 and 25-foot inside diameters. They hold 12,500 and 33,000 tile respectively, and are fired by wood and coal.

TABLE 45 Partial Chemical Analyses: Continental Brick and Tile Company

	Queenston shale bulk sample (*percent*)	Dundas shale bulk sample (*percent*)
Fe_2O_3	6.12	7.22
CaO	17.3	3.07
Loss on ignition	19.34	6.76
Soluble salts	0.44	0.66

TABLE 46 Mineral Analyses: Continental Brick and Tile Company
(A = abundant; B = moderate; C = minor; D = trace; ND = not detected)

	Queenston shale bulk sample (*percent*)	Dundas shale bulk sample (*percent*)
Non-clay minerals		
Quartz	12	29
Calcite	16	2
Dolomite	9	ND
Soda-lime feldspar	ND	<0.5
Potash feldspar	ND	ND
Clay minerals		
Illite	A	A
Chlorite	B	A
Expanding minerals	C	D

TABLE 47 Ceramic Tests: Continental Brick and Tile Company

SAMPLE: Queenston shale, bulk sample

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	3.3
Pyrometric cone equivalent	5–6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	0.5	0.3
Colour	salmon	light salmon	buff
Hardness	hard	almost hard	almost hard
24-hour absorption (%)	17.8	16.0	15.9
5-hour boil absorption (%)	18.6	17.4	20.7
Specific gravity	1.67	1.66	1.65

SAMPLE: Dundas shale, bulk sample

Water of plasticity (*percent*)	23
Lineal drying shrinkage (*percent*)	4.2
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	5.6	6.9
Colour	light brown	red-brown	red-brown
Hardness	almost hard	very hard	very hard
24-hour absorption (%)	12.7	4.5	0.5
5-hour boil absorption (%)	13.5	5.6	0.6
Specific gravity	1.93	2.23	2.41

REMARKS: Scum is common on briquettes fired at cones 06 and 03.

GEOLOGY

Red-brown weathered Queenston shale and grey Dundas shale are obtained locally. The results of chemical, mineralogical, and ceramic testing of small bulk samples taken from stockpiles of these materials at the plant are given in tables 45, 46, and 47.

DIAMOND CLAY PRODUCTS LIMITED

One of the newest brick plants in the province is that of Diamond Clay Products Limited at Tansley on Highway no. 5. It commenced brick production in the spring of 1959, using Queenston shale from the valley of nearby Bronte Creek. The plant and pit are located in lots 3 and 4, concession I, N.D.S., Nelson township, Halton county.

Plant

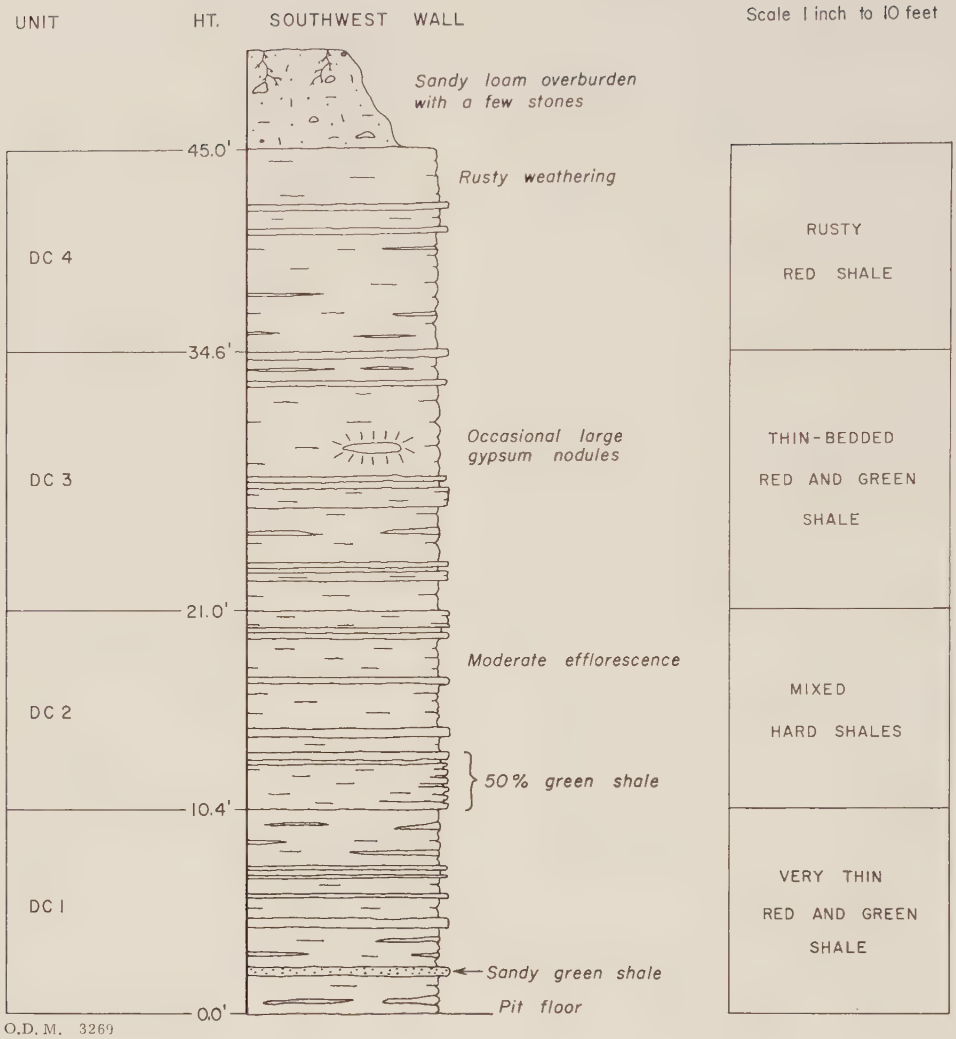
The production is 90 percent Ontario brick, predominantly in shades of buff and brown, but American, Norman, Roman, and Modular sizes are also made. Capacity of the plant is rated at 34 million brick annually.

Quarrying of the shale and trucking to the plant are done by contract. Up to 10 feet of sandy loam and pebbles are stripped from the quarry area by bulldozer. The shale is drilled and blasted, and is loaded into dump trucks by a power shovel. Haulage distance to the plant is about 1,000 feet. A Michigan loader with a 2½-yard front-end bucket reclaims the shale from a large open-air stockpile and loads the primary crusher bin. The shale is delivered by apron feeder to a 36-inch Bradley and Craven counter-rotating toothed-roll crusher discharging at about 2-inch. Grinding is accomplished in a 10-foot Bradley and Craven drypan with rim discharge. Five 4 by 7-foot Tyler heated vibrating 14-mesh screens are in closed circuit with a 40-inch diameter, 26-inch, Handle smooth double-roll crusher. Ground shale is stored by overhead conveyor in a Butler-type building 120 by 60 feet in area.

The brick circuit is fed either by direct conveyor, or alternatively by a ½-yard Hough Payloader, which loads the ground shale into an 8-foot square bin feeder. Additives are proportioned onto the belt by other bins and feeders, and the mix is discharged into a Steele #50 pug mill where tempering water is added. A Steele #60 combined pugging, de-airing, auger machine extrudes the brick column under a vacuum of 27 inches. The normal range of textures can be applied to the column before it is cut by a Steele #18 cutter. Ten hackers stack the green brick onto cars travelling on wide-gauge tracks. Each car is 9 feet 4 inches long and holds 3,600 Ontario-size brick.

A 4-track waste-heat tunnel dryer 120 feet long holds 12 cars on each track. Temperature in the tunnel grades from 120°F at the start to 400°F at the hot end, and drying time is 2 days. Two Swindell-Dressler tunnel kilns are 290 feet long and hold 30 cars each. They are fired by natural gas to about 1900°F. A 2-hour push permits a burning cycle of 60 hours.

Bricks are graded for colour, and bound in units of 400. Shipments are made by truck and rail.


UNIT
HT.
SOUTHWEST WALL
Scale 1 inch to 10 feet
Sandy loam overburden with a few stones
45.0'
Rusty weathering
DC 4
RUSTY RED SHALE
34.6'
Occasional large gypsum nodules
DC 3
THIN-BEDDED RED AND GREEN SHALE
21.0'
Moderate efflorescence
DC 2
MIXED HARD SHALES
50 % green shale
10.4'
DC 1
VERY THIN RED AND GREEN SHALE
Sandy green shale
0.0'
Pit floor
O.D.M. 3269

Unit		Thickness (*feet*)
DC 4	SHALE: Red with occasional green lenses; very thin to laminated bedding; some rusty weathering.	10.4
DC 3	SHALE: Red with a few green lenses; thin-bedded; occasional large gypsum nodules.	13.6
DC 2	SHALE: Mixed green and red, diffusely coloured; hard; laminated to very thin bedded;	10.6
DC 1	SHALE: Red with green lenses and mottlings and several discreet hard green beds; hard; very thin-bedded.	10.4

Figure 12—Diamond Clay Products Ltd., quarry section.

TABLE 48 Chemical Analyses: Diamond Clay Products Limited

	Depth from surface in feet						Composite*
	0.0–10.0	10.0–15.0	15.0–25.0	25.0–35.0	35.0–45.0	45.0–52.0	0.0–52.0
	(percent)	*(percent)*	*(percent)*	*(percent)*	*(percent)*	*(percent)*	*(percent)*
SiO_2							45.10
Al_2O_3							11.9
Fe_2O_3	4.52	5.39	4.72	4.90	5.33	4.67	4.57
CaO	17.7	13.16	16.4	16.2	11.2	12.8	14.3
MgO							2.63
Na_2O							0.81
K_2O	2.90	3.34	3.01	3.15	3.34	3.07	2.99
TiO_2							0.67
CO_2							12.47
H_2O+							2.13
H_2O-							0.58
SO_3	0.12	0.03	0.04	0.09	0.23	0.05	0.32
TOTAL							98.5
Loss on ignition	17.36		16.36	14.02	13.28	14.82	15.49
Soluble salts	0.64		0.41	0.66	0.85	0.70	

*Section 10.0–15.0 not included.

TABLE 49 Mineral Analyses: Diamond Clay Products Limited
(A = abundant; B = moderate; D = trace; ND = not detected)

	Depth from surface in feet					Composite*
	0.0–10.0	15.0–25.0	25.0–35.0	35.0–45.0	45.0–52.0	0.0–52.0
	(percent)	*(percent)*	*(percent)*	*(percent)*	*(percent)*	*(percent)*
Non-clay minerals						
Quartz	21	22	30	29	23	25
Calcite	30	28	24	19	20	24
Dolomite	2	2	<0.5	3	5	4
Soda-lime feldspar	<0.5	3	3	3	3	3
Potash feldspar	1	ND	ND	1	1	<0.5
Clay minerals						
Illite	A	A	B	A	A	A
Chlorite	B	B	B	B	B	B
Expanding minerals	ND	ND	ND	ND	D†	ND

*Section 10.0–15.0 not included.
†Vermiculite.

TABLE 50 Ceramic Tests: Diamond Clay Products Limited

SAMPLE: Top of drillhole No. 1: 0.0′–10.0′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.5
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.7	1.7	2.2
Colour	salmon-pink	pink-tan	grey-buff
Hardness	moderately soft	almost hard	hard
24-hour absorption (%)		21.5	19.6
5-hour boil absorption (%)		24.7	24.9
Specific gravity		1.66	1.64

REMARKS: Briquettes fired at cone 010 crumbled on exposure to the air.

SAMPLE: 15.0′–25.0′

Water of plasticity (*percent*)	15
Lineal drying shrinkage (*percent*)	2.6
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.7	1.7	1.9
Colour	salmon-pink	tan	grey-buff
Hardness	almost hard	almost hard	almost hard
24-hour absorption (%)	20.9	20.1	18.9
5-hour boil absorption (%)	22.6	24.1	24.6
Specific gravity	1.70	1.66	1.65

REMARKS: Briquettes fired at cone 010 exhibit moderate cracking on exposure to the air.

SAMPLE: 25.0′–35.0′

Water of plasticity (*percent*)	15
Lineal drying shrinkage (*percent*)	2.3
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	1.4	1.5	1.2
Colour	salmon-pink	tan-buff	yellow-buff
Hardness	almost hard	hard	hard
24-hour absorption (%)	19.1	18.4	16.1
5-hour boil absorption (%)	21.0	22.4	21.7
Specific gravity	1.75	1.70	1.72

REMARKS: Briquettes are slightly warped, blistered, and overfired at cone 03. Moderate scumming on briquettes fired at cones 010 and 06.

SAMPLE: 35.0′–45.0′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.7
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.5	1.4	1.4
Colour	salmon-pink	cream-pink	green-yellow
Hardness	almost hard	hard	hard
24-hour absorption (%)	16.6	16.9	15.4
5-hour boil absorption (%)	19.4	20.5	19.9
Specific gravity	1.78	1.75	1.75

REMARKS: Briquettes are slightly warped and overfired at cone 03. Scumming is moderate on briquettes fired at cones 010 and 06.

SAMPLE: Bottom of drillhole No. 1: 45.0′–52.0′

Water of plasticity (*percent*)	15
Lineal drying shrinkage (*percent*)	2.6
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.7	2.1	1.9
Colour	salmon-pink	cream	buff
Hardness	moderately soft	moderately soft	almost hard
24-hour absorption (%)	18.2	17.8	16.9
5-hour boil absorption (%)	21.3	22.1	22.7
Specific gravity	1.75	1.71	1.69

REMARKS: Briquettes fired at cone 03 are slightly warped. Briquettes fired at cones 010 and 06 are marked by a little scum.

ODM7448

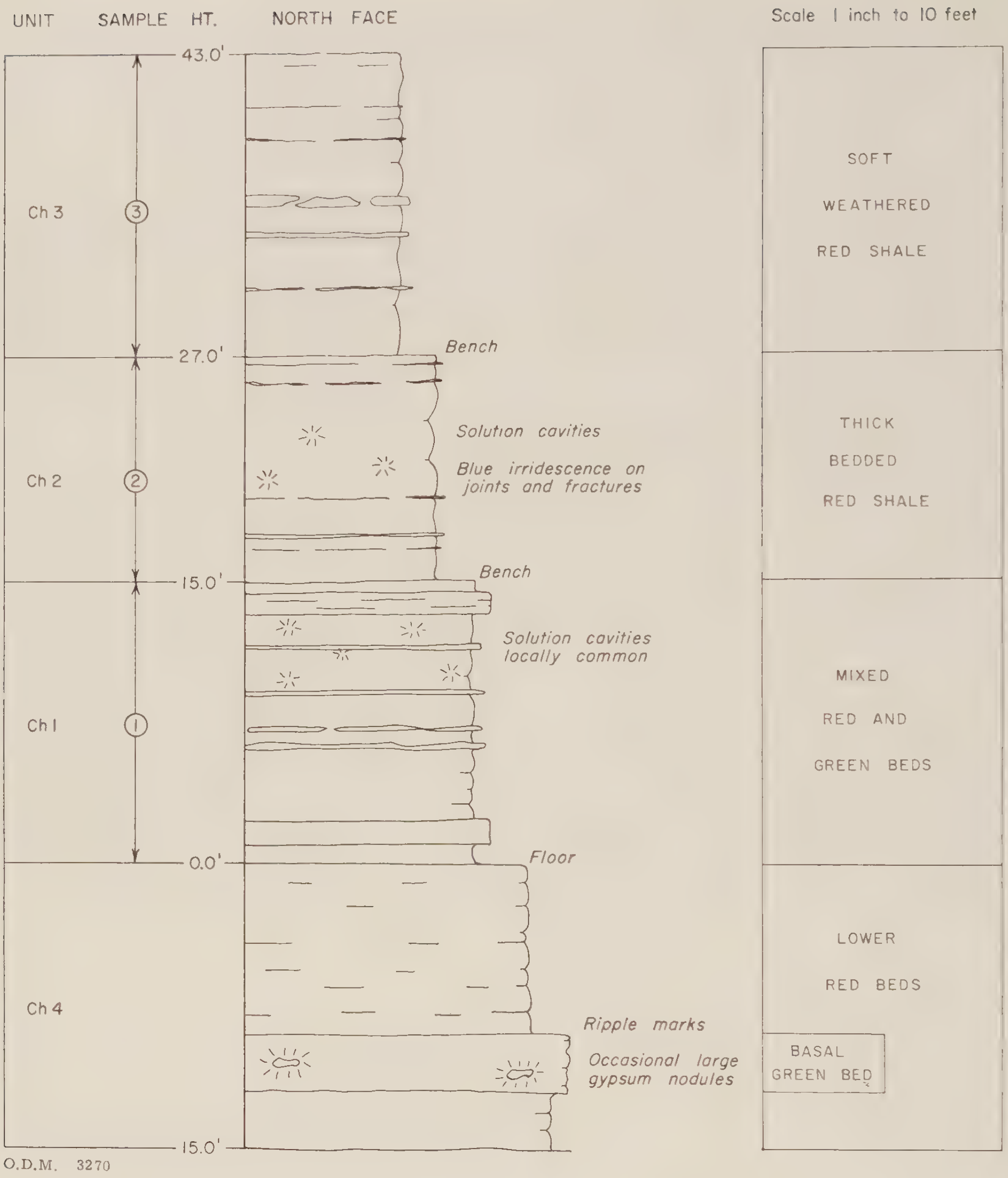
Photo 23—Diamond Clay Products Limited; shale quarry 1965.

GEOLOGY

The 45-foot quarry face exposes a mixed shale section rarely observed in the Queenston Formation. The section consists of an intimate mixture of thin- to very thin-bedded red and green shales that are much more limy over-all than the average Queenston shale section. The site was chosen particularly because of the company's interest in producing brick in the lighter colour ranges.

The shale section is illustrated and described in figure 12. It is difficult to divide it into distinctive geological units. The section as a whole is a uniform, very thin-bedded, almost alternating assemblage of rather hard red and green layers. Beds of grey-green or yellow-green limy shale comprise 20–30 per cent. Rounded gypsum nodules up to 12 inches are occasionally embedded in the red shale.

Prior to opening their quarry on the west side of Bronte Creek the company carried out core-drilling of the area on a 100-foot grid pattern. Representative portions of the 2-inch core for hole no. 1 were made available to the writer for testing and analysis. Hole no. 1 was drilled from the original bedrock surface to a depth of 52 feet in the west-central part of the quarry. The results of chemical, mineralogical, and ceramic testing are given in tables 48, 49, and 50. Only the 5-foot section at a depth of 10–15 feet was unavailable; the company supplied the partial chemical analysis for the missing section, as reported in Table 48. Their analyses for K_2O and SO_3 are also shown with the partial analyses for the individual samples.


UNIT
SAMPLE
HT.
NORTH FACE
Scale 1 inch to 10 feet
43.0'
Ch 3
③
SOFT
WEATHERED
RED SHALE
27.0'
Bench
Solution cavities
Blue irridescence on joints and fractures
Ch 2
②
THICK
BEDDED
RED SHALE
15.0'
Bench
Solution cavities locally common
Ch 1
①
MIXED
RED AND
GREEN BEDS
0.0'
Floor
Ch 4
LOWER
RED BEDS
Ripple marks
Occasional large gypsum nodules
BASAL
GREEN BED
15.0'
O.D.M. 3270

Unit		Thickness (*feet*)
Ch 3	Shale: Red, with 5 percent green shale; soft; thick-bedded; green "eyes" up to 1-inch diameter common in red shale; nodular rusty weathering.	16.0
Ch 2	Shale: Red, with 2 percent green shale in mottled thin discontinuous lenses; soft; thick-bedded; occasional green "eyes" to 1-inch; nodular rusty weathering; occasional solution cavities to 1-inch in length; blue irridescence common on joint and fracture surfaces.	12.0
Ch 1	Shale: Mixed red and green; moderately hard; medium and thick-bedded; rare ⅛-inch green "eyes"; nodular weathering; small solution cavities common in upper beds.	15.0
Ch 4	Shale: Red; moderately soft; one prominent 3-foot green zone is laminated to thin-bedded and contains occasional large gypsum nodules and ripple marks.	15.0

Figure 13—Cheltenham, quarry section.

TABLE 51 Chemical Analyses: Cheltenham Quarry

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–15.0	15.0–27.0	27.0–43.0	0.0–43.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				48.46
Al_2O_3				14.2
Fe_2O_3	5.82	6.35	6.30	6.03
CaO	10.9	8.00	7.60	9.98
MgO				4.77
Na_2O				0.31
K_2O				3.90
TiO_2				0.65
CO_2				8.27
H_2O+				2.99
H_2O-				0.78
SO_3				0.22
TOTAL				100.6
Loss on ignition	13.61	11.87	11.83	12.07
Soluble salts	0.54	0.22	0.26	

TABLE 52 Mineral Analyses: Cheltenham Quarry
(A = abundant; B = moderate; ND = not detected)

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–15.0	15.0–27.0	27.0–32.0	0.0–43.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	20	20	21	21
Calcite	15	11	10	11
Dolomite	2	5	3	4
Soda-lime feldspar	ND	ND	ND	ND
Potash feldspar	ND	ND	ND	ND
Clay minerals:				
Illite	A	A	A	A
Chlorite	B	B	B	B
Expanding minerals	ND	ND	ND	ND

TABLE 53 Ceramic Tests: Cheltenham Quarry

SAMPLE 1: 0.0′–15.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.9
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.1	0.3 (expansion)	0.1
Colour	salmon	salmon	light brown
Hardness	hard	hard	very hard
24-hour absorption (%)	14.5	14.0	12.3
5-hour boil absorption (%)	16.4	17.3	16.7
Specific gravity	1.84	1.82	1.84

REMARKS: Briquettes have a mottled colouring due to slight overfiring at cone 03.

SAMPLE 2: 15.0′–27.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.3
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.1	0	0
Colour	salmon	salmon	salmon-brown
Hardness	hard	hard	very hard
24-hour absorption (%)	12.4	11.9	10.1
5-hour boil absorption (%)	14.4	14.8	13.9
Specific gravity	1.89	1.88	1.88

REMARKS: Briquettes have a mottled colouring due to slight overfiring at cone 03.

SAMPLE 3: 27.0′–43.0′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	3.4
Pyrometric cone equivalent	4–5

	Cones		
	010	06	03
Lineal firing shrinkage (%)	0	0.5	0.7
Colour	salmon	salmon-red	pink-brown
Hardness	hard	hard	very hard
24-hour absorption (%)	12.6	12.0	10.5
5-hour boil absorption (%)	14.5	15.0	13.7
Specific gravity	1.88	1.88	1.90

REMARKS: Smooth-textured attractive briquettes at all firing temperatures.

DOMTAR CONSTRUCTION MATERIALS LIMITED, CHELTENHAM

Dry-pressed brick were formerly produced at a plant on the C.N.R. one mile southwest of Cheltenham in Peel county. The plant was built in 1912 and had been in the Domtar group (originally the Cooksville Company) since 1928. It was officially closed on January 1, 1965. An early description is given by Montgomery (1930, p. 149).

GEOLOGY

A quarry near Cheltenham which was operated until recent years is located in lot 29, concession IV, Chinguacousy township, Peel county. The quarry opens to the south, and was worked in a northerly direction along a semicircular face about 700 feet long. The 43-foot section of Queenston shale was worked in three benches, and a further 15 feet of shale was poorly exposed in old workings below the quarry floor.

A section through the north wall of the quarry is illustrated and described in Figure 13. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in the accompanying tables (51, 52, and 53).

DOMTAR CONSTRUCTION MATERIALS LIMITED, OTTAWA

This plant commenced operating in the fall of 1961. It replaces the Ottawa Brick and Terra Cotta Co. Ltd. which ceased operations in May 1960. Location of the plant is at South Gloucester, some 10 miles southeast of Ottawa on the east side of Highway no. 31. Red shale is trucked 16 miles to the plant from a Queenston shale quarry near Russell. Early references to brick-making at Ottawa are contained in reports by Baker (1906, p. 60), Keele (1924, pp. 60, 65, 69), and Montgomery (1930, p. 111).

Plant

The plant is rated at 24 million brick per year, but the layout makes provision for further drying facilities and a second tunnel kiln when the market requires it. Brick are produced in standard sizes with a full range of textures and colours. Forty-six men are employed in the plant in all capacities including supervision. Quarrying and trucking of the shale is by contract.

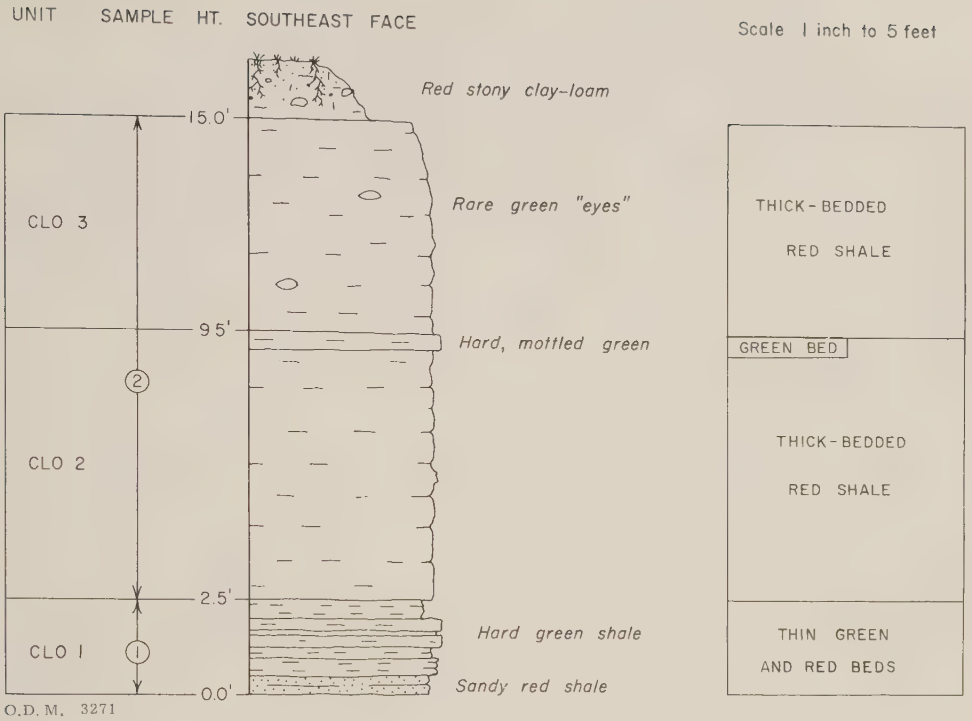
The 25-foot face of predominantly red shale is broken by drilling and blasting and loaded into trucks by a tractor-mounted front-end loader. A 60,000-ton open-air stockpile is built-up at the plant during the summer season. Shale is reclaimed by a large rubber-mounted front-end loader. The plant feed is reduced to 2-inch by a heavy impact crusher capable of handling 200 tons per hour. A 10-foot diameter dry-pan and a hammer mill complete the reduction of the shale. Screening is done at 16-mesh by four 5-foot by 8-foot heated vibrating screens. The screened material grades about 40 percent minus 100-mesh. It is stored in two 200-ton silos and transferred by conveyor belt to the first pugging section. Discharge from the pug mill goes directly into a large combined pug and auger machine capable of extruding 20,000 brick per hour. The stream is cut by an automatic cutter making 21 bricks with each cycle. The brick are hacked manually, 5,000 per car, and remain on the same cars throughout the drying and firing sequence.

A 4-track holding room has space for 32 cars ahead of the dryers. The 2 waste-heat tunnel dryers accommodate 14 cars each. Drying time is normally 2 days and the temperature at the hot end is 360°F. Gas heating augments the supply of waste heat when required. A 400-foot tunnel kiln has room for 38 cars. It is also gas-fired and the peak temperature in the heat zone is 1925°F. Progression through the kiln is by a continuous hydraulic push set for a production of one car about every 2 hours.

Brick are palletized in 500-brick cubes and are stocked in the yard to await truck shipment.

GEOLOGY

A small area of Queenston shale straddles the boundary between Carleton and Russell counties 15–20 miles southeast of Ottawa. A quarry in lot 18, concession III, Russell township, Russell county, exposed a 15-foot section of shale at the time of the writer's visit in 1961, and a further 15–25 feet of red shale was said to have been proved by drilling below the floor. The quarry was formerly worked by Ottawa


UNIT
SAMPLE HT.
SOUTHEAST FACE
Scale 1 inch to 5 feet
Red stony clay-loam
15.0'
CLO 3
Rare green "eyes"
THICK-BEDDED
RED SHALE
9.5'
Hard, mottled green
GREEN BED
②
CLO 2
THICK-BEDDED
RED SHALE
2.5'
Hard green shale
THIN GREEN
AND RED BEDS
CLO 1
①
0.0'
Sandy red shale
O.D.M. 3271

Unit		Thickness (*feet*)
CLO 3	**Shale**: Uniformly red; rather hard; thick-bedded; rare ½-inch green "eyes"; rusty joint planes; blocky weathering at top.	5.5
CLO 2	**Shale**: Uniformly red except for one hard mottled green layer at top; hard; thick-bedded; green alteration on joint planes.	7.0
CLO 1	**Shale**: Mixed green and red; variable hard to soft; thin-bedded to laminated; several seams of red mud between harder layers.	2.5

Figure 14–Russell county, shale quarry section.

Table 54 Chemical Analyses: Shale Quarry, Russell County

Sample	1	2	Composite
Height above floor (*feet*)	0.0–2.5	2.5–15.0	0.0–15.0
	(*percent*)	(*percent*)	(*percent*)
SiO_2			58.06
Al_2O_3			15.9
Fe_2O_3	4.98	6.72	6.28
CaO	6.20	4.45	4.48
MgO			2.78
Na_2O			1.21
K_2O			3.42
TiO_2			0.75
CO_2			3.67
H_2O+			3.13
H_2O-			0.67
SO_3			0.62
Total			101.0
Loss on ignition	7.90	7.11	7.14
Soluble salts	0.92	0.82	

Table 55 Mineral Analyses: Shale Quarry, Russell County

(A = abundant; B = moderate; D = trace; ND = not detected)

Sample	1	2	Composite
Height above floor (*feet*)	0.0–2.5	2.5–15.0	0.0–15.0
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	30	28	32
Calcite	11	7	6
Dolomite	ND	ND	ND
Soda-lime feldspar	7	3	5
Potash feldspar	ND	ND	<0.5
Clay minerals			
Illite	A	A	A
Chlorite	B	B	B
Expanding minerals	ND	D*	ND

*Vermiculite

TABLE 56 Ceramic Tests: Shale Quarry, Russell County

SAMPLE 1: 0.0′–2.5′

Water of plasticity (*percent*)	15
Lineal drying shrinkage (*percent*)	2.6
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.8	1.4	1.4
Colour	salmon-brown	pink-brown	yellow-brown
Hardness	moderately soft	moderately soft	moderately soft
24-hour absorption (%)	13.6	13.3	11.7
5-hour boil absorption (%)	15.9	16.8	15.9
Specific gravity	1.87	1.84	1.83

REMARKS: Fired briquettes are soft at all temperatures, and are marked by a moderate amount of scum.

SAMPLE 2: 2.5′–15.0′

Water of plasticity (*percent*)	15
Lineal drying shrinkage (*percent*)	2.7
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7 (expansion)	0.9 (expansion)	0.8
Colour	dark salmon	dark salmon	dark red
Hardness	moderately soft	almost hard	hard
24-hour absorption (%)	11.1	10.5	5.6
5-hour boil absorption (%)	13.2	13.2	9.0
Specific gravity	1.95	1.94	2.01

REMARKS: Briquettes are slightly blistered and overfired at cone 03.

Brick and Terra Cotta Company Limited. The workings are shallow and cover a large area in low flat terrain. Pumping is necessary to keep the quarry dry. A red stony clay loam 1–4 feet thick is stripped from above the shale. The upper 3–4 feet of soft weathered shale can be removed without blasting.

The southeast face of the quarry is illustrated in figure 14. A geological description of the shale units, and the results of chemical, mineralogical, and ceramic testing, are given in accompanying tables, 54, 55, and 56.

GRIMSBY TILE LIMITED

Grimsby Tile Limited is located 3 miles east of Grimsby in lot 23, concession I, Clinton township, Lincoln county. The plant is over 90 years old. It was primarily a brick producer through much of its early history but has been solely a tile producer since 1955. Early descriptions of this plant are contained in reports by Baker (1906, pp. 78–79) and Montgomery (1930, p. 135).

Plant

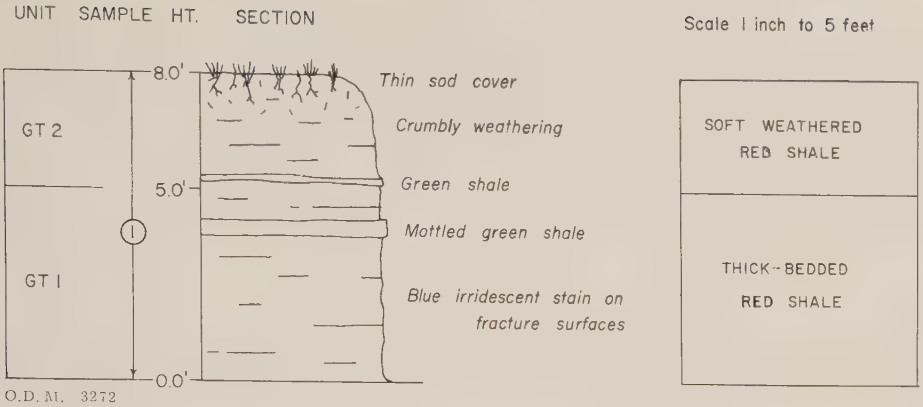
Some 6 million drain tile are produced annually in sizes ranging from 3 to 8 inches in diameter. Chimney flues are also made in 8 × 8 × 24-inch sizes. The plant employs 35 men the year-round.

The soft weathered shale is taken from the bank by a 1½-yard HT4 Caterpillar front-end loader and trucked some 600 feet to the plant. It is received by hopper at the plant and is passed to a 24-inch single-toothed roll, discharging at minus 2-inch. A 9-foot diameter drypan is in closed circuit with a single 4 × 8-foot, 16-mesh, vibrating screen. Ground shale is stored in a 50-ton wooden bin. Small diameter tile are extruded in a double stream at the rate of 12 tons per hour by an American combined pugging, de-airing, auger machine. The tile are cut by an F-R-H No. 731 cutter and are hacked on cars, about 1,200 pounds per car.

There are 9 tunnel dryers having a total capacity of 150 cars. They are fired with natural gas, and the ware is dried for 24 hours; temperature at the hot end is 200°F. Four rectangular downdraft kilns hold 40,000 tile each. A single beehive kiln holds 14,000 tile. All are coal-fired to peak temperatures of 1800°F and are on-fire for 80 hours. A 7-day turnover cycle is possible at peak capacity.

GEOLOGY

Weathered Queenston shale underlies a few inches of shale soil in the vicinity of the Grimsby Tile plant. Excavation of the top 8–12 feet of the shale has been carried on over an area of 20 acres. The shale section is illustrated in figure 15 and described in the accompanying notes. Chemical, mineralogical, and ceramic test results are given in tables 57, 58, and 59.


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
GT 2
GT 1
8.0'
5.0'
0.0'
①
Thin sod cover
Crumbly weathering
Green shale
Mottled green shale
Blue irridescent stain on fracture surfaces
SOFT WEATHERED RED SHALE
THICK-BEDDED RED SHALE
O.D.M. 3272

Unit		Thickness *(feet)*
GT 2	SHALE: Light red to brown; soft; crumbly weathering; topped by a few inches of brown shale-clay soil and sod.	3.0
GT 1	SHALE: Red with minor green shale; soft; thick-bedded; blocky weathering; blue irridescent stain on occasional harder fragments.	5.0

Figure 15—Grimsby Tile Ltd., quarry section.

TABLE 57 Chemical Analysis: Grimsby Tile Limited

Height above floor *(feet)*	(1) 0.0–8.0
	(percent)
SiO_2	56.28
Al_2O_3	16.0
Fe_2O_3	6.77
CaO	4.74
MgO	2.55
Na_2O	0.70
K_2O	3.93
TiO_2	0.85
CO_2	3.81
H_2O+	3.21
H_2O-	0.92
SO_3	0.33
TOTAL	100.1
Loss on ignition	7.81

TABLE 58 Mineral Analysis: Grimsby Tile Limited (A = abundant; C = minor; ND = not detected)

Height above floor *(feet)*	(1) 0.0–8.0
	(percent)
Non-clay minerals	
Quartz	30
Calcite	6
Dolomite	ND
Soda-lime feldspar	2
Potash feldspar	<0.5
Clay minerals	
Illite	A
Chlorite	C
Expanding minerals	ND

TABLE 59 Ceramic Tests: Grimsby Tile Limited

SAMPLE 1: 0.0′–8.0′

Water of plasticity *(percent)*	21
Lineal drying shrinkage *(percent)*	4.3
Pyrometric cone equivalent	5–6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5	1.7	3.1
Colour	orange salmon	salmon red	red-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	12.5	10.6	6.3
5-hour boil absorption (%)	14.2	12.9	8.8
Specific gravity	1.88	1.94	2.06

REMARKS: Briquettes are slightly overfired and contain a trace of scum at cone 03.

MILNE 51338-10

Photo 24–Hamilton Brick Limited; beehive kilns 1960. (Photo by Gilbert A. Milne and Co. Ltd.; courtesy Canadian Structural Clay Association, Willowdale.)

HAMILTON BRICK LIMITED

A plant located at 215 Kensington Avenue at the base of the Hamilton mountain produces both stiff-mud and dry-pressed brick. The plant was built by the New family in 1907 and sold to the Collingwood Shale Brick and Supply Company of Cleveland in 1955. Although an 80-foot face of Queenston Shale exists behind the plant, most of the raw materials have been trucked from outside quarries in recent years. An early description of the plant is given by Montgomery (1930, p. 159).

Plant

The annual production averages 12 million brick —predominantly Ontario size, in red or flashed colours. The plant operates the year-round and employs 33 men.

Queenston shale from the Waterdown quarry of the National Sewer Pipe Company is trucked 9 miles to the plant and stockpiled. A mixture of weathered shale and surface clay is scraped by bulldozer into a separate stockpile at the plant site. The two materials are batched in equal portions by a 1¼-yard Caterpillar Traxcavator No. 955 front-end loader and trucked to the feed hopper. Grinding is accomplished by a 10-foot Bonnot drypan, and minor amounts of barium carbonate, manganese dioxide, and Lignosol can be added directly to the pan by separate bins and feeders.

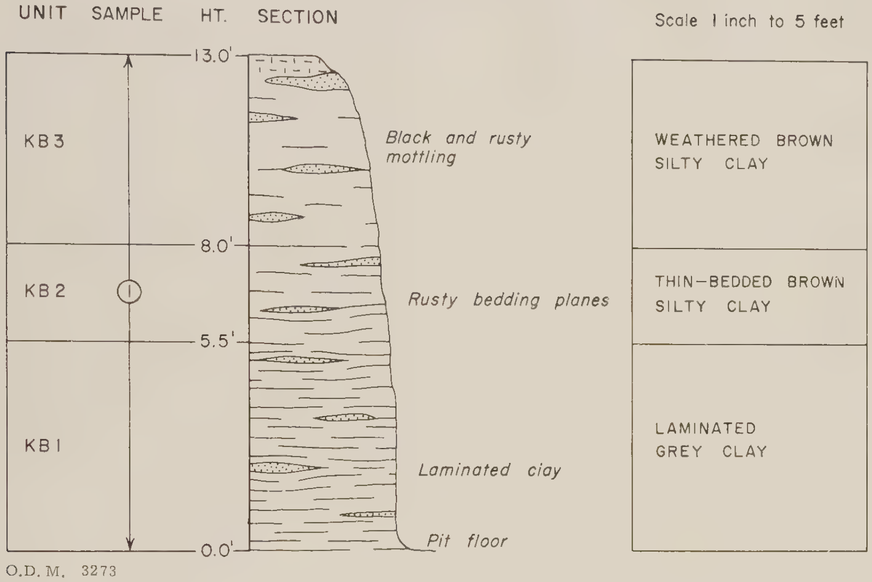
The drypan is in closed circuit with two 4-foot by 5-foot Tyler vibrating and heated screens. A small wooden bin provides limited storage for the 8-mesh product. A Bonnot Greyhound Vacuum Extruder with double pugging produces brick at the rate of 45,000 per day. The first pugging section is directly beneath the storage bin and receives the shale by disc feeder. Normal texturing is applied to the extruded stream before cutting by a Steele No. 18 cutter. The brick are hacked in units of 350, 2 units per car, and all subsequent handling is by forklift truck. Minor production of dry-pressed brick is accomplished by a Berg machine, operating at 1,700 brick per hour.

An 8-track tunnel dryer holds 15 cars on each track. It is heated by gas, and the drying time is 48 hours at 190°F. Ten beehive kilns of 38-foot diameters will each hold 100,000 brick when stacked by forklift or 130,000 if manually set. They are fired with soft coal to a peak temperature of 1870°F, and the burning cycle is 96 to 100 hours. The kilns can be turned over on a 10 or 12 day cycle.

Bricks are stocked in the yard in cubes of 500, and shipments are made by truck.

KITCHENER BRICK COMPANY LIMITED

The plant of Kitchener Brick Company Limited is located at 60 Heiman Street, in Kitchener. It was built in 1885 and was operated by the Ott family for many years. Latterly it was owned by the Seegmillers, but in 1951 it was purchased by Detroit interests. Early descriptions of the plant are given by Baker (1906, p. 104) and Montgomery (1930, p. 156).


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
13.0'
KB 3
Black and rusty mottling
WEATHERED BROWN SILTY CLAY
8.0'
KB 2
①
Rusty bedding planes
THIN-BEDDED BROWN SILTY CLAY
5.5'
KB 1
LAMINATED GREY CLAY
Laminated clay
Pit floor
0.0'
O.D.M. 3273

Unit		Thickness (*feet*)
KB 3	CLAY: Medium brown with black and rusty mottlings; weathering to grey-yellow; silty, stoneless; structureless; pods of fine yellow-orange sand are common.	5.0
KB 2	CLAY: Variegated yellow-brown to medium brown, weathering to grey-yellow; silty, stoneless; thin-bedded; rusty bedding planes and joints; pods of fine yellow-orange sand.	2.5
KB 1	CLAY: Medium grey, weathering to very light grey; dense; stoneless; laminated; small-irregular lenses and pods of fine yellow-orange sand are common.	5.5

Figure 16–Kitchener Brick Co. Ltd., clay section.

TABLE 60 Chemical Analysis:
Kitchener Brick Company Limited

Height above floor (*feet*)	(1) 0.0–13.0
	(*percent*)
SiO_2	46.72
Al_2O_3	9.62
Fe_2O_3	4.22
CaO	16.7
MgO	3.90
Na_2O	1.42
K_2O	2.73
TiO_2	0.48
CO_2	13.32
H_2O+	1.44
H_2O-	0.67
SO_3	0.25
TOTAL	101.5
Loss on ignition	16.26

TABLE 61 Mineral Analysis:
Kitchener Brick Company Limited
(B = moderate; C = minor)

Height above floor (*feet*)	(1) 0.0–13.0
	(*percent*)
Non-clay minerals	
Quartz	22
Calcite	17
Dolomite	8
Soda-lime feldspar	5
Potash feldspar	1
Clay minerals	
Illite	B
Chlorite	B
Expanding minerals	C

TABLE 62 Ceramic Tests: Kitchener Brick Company Limited

SAMPLE 1: 0.0′–13.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	3.2
Pyrometric cone equivalent	2

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.5 (expansion)	0.7 (expansion)
Colour	tan	light tan	cream
Hardness	soft	soft	almost hard
24-hour absorption (%)	21.0	20.4	19.0
5-hour boil absorption (%)	20.9	22.9	23.8
Specific gravity	1.68	1.65	1.64

Plant

Six million brick are produced annually in red, buff, and brown colours. Some 4- and 6-inch drain tile are also made. The operation is continuous throughout the year and employs 20 men.

Red-burning Queenston shale is trucked to the plant from the Waterdown quarry of National Sewer Pipe Limited. Buff-burning clay is obtained from a small roadside pit 4 miles south of Brantford. Shale is stockpiled in the yard to take advantage of the benefits of natural weathering, and an enclosed storage area for clay has a capacity of 10,000 yards. A John Deere No. 420 front-end loader batches the two materials as required and loads them into a 9-foot Raymond drypan. In the production of red brick the feed is entirely Queenston shale, and the occasional limy green fragments are hand-sorted and rejected. Buff colours are produced by the addition of clay in amounts dependent on the colour desired, but it is normal to have at least one-third of the body composed of shale. A 4-foot by 7-foot Leahy heated vibrating screen is in closed circuit with the drypan. The minus 14-mesh material is delivered by a Meco disc feeder to a 10-foot Parkhill single-shaft pug mill. An F-R-H Hummer de-airing auger machine is operated at the rate of 4,200 brick per hour with a vacuum of 26 inches. Cut-off is by a Frey Universal cutter. The brick are hacked 600 to a car.

A 6-track waste-heat tunnel dryer 150 feet long has a capacity of 22 cars on each track for a total drying capacity of 135,000 brick. Drying time is about 3 days and temperature at the hot end is 200°F. Six beehive kilns of about 26-foot diameters hold an average of 45,000 brick each. They are fired with gas to 1850°F and are turned over on a 12-day cycle. Shipments are made by truck in cubes of 400-brick.

GEOLOGY

The major portion of the plant feed is Queenston shale from the Waterdown quarries of National Sewer Pipe Limited. The shale section is described under the heading of the latter company.

Buff-burning clay is added to the red-burning shale in various proportions, largely for colour control. Clay forms as much as 65 percent of the batch for buff brick, whereas red brick is 100 percent shale.

In 1961 clay was being obtained from a roadside pit in Brant township, Brant county, on the Sour Springs Road 5 miles south of Brantford. The 13-foot clay bank contains numerous pods of fine sand and is oxidized brown in the top half. The section is illustrated in figure 16 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of a vertical channel sample are given in the accompanying tables, 60, 61, and 62.

F. B. McFARREN, LIMITED

A plant located on the southern limits of Streetsville was built in 1913 and purchased by F. B. McFarren in 1929. The shale quarry and the plant are in lot 3, concession V W.H.S. Toronto township, Peel county. Early references to brick-making on this site are contained in reports by Keele (1924, p. 22) and Montgomery (1930, p. 148).

Plant

Brick are produced in a complete range of colours and textures in the standard Ontario size. The annual production is about 10 million brick, all made by the stiff-mud method.

Queenston shale is removed by drilling 8-foot horizontal holes with jack-hammer along the base of the face at 8 or 10-foot intervals. These are “popped” by very light charges of dynamite, and the resulting pockets at the ends of the holes are heavily loaded and the whole face detonated electrically. The broken shale is loaded by a 1½-yard front-end Massey Ferguson loader and hauled by truck some 500 feet to the plant. It is dumped onto a covered ramp in the

TABLE 63 Chemical Analyses: F. B. McFarren, Limited

Sample	1	2	3	4	Composite
Height above floor (*feet*)	−14.0 to −11.6	−11.6 to −10.0	0.0–14.0	14.0–22.0	0.0–22.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2					55.97
Al_2O_3					13.4
Fe_2O_3	4.70	5.63	6.79	6.72	6.58
CaO	7.68	7.57	6.53	5.11	6.34
MgO					2.68
Na_2O					0.76
K_2O					3.25
TiO_2					0.80
CO_2					5.24
H_2O+ (*combined*)					2.53
H_2O- (*moisture*)					0.99
SO_3					0.20
TOTAL					98.7
Loss on ignition	9.34	9.58	9.02	8.28	8.80
Soluble salts	0.44	0.53	0.52	0.48	

grinding section and scraped manually onto a subfloor conveyor through draw points in the floor. Occasional large, hard, green shale fragments are sorted and rejected. The rest is discharged to a drypan. The shale is screened at 10-mesh on a single 7-foot by 4-foot Leahy heated vibrating screen. A 30 by 36-inch Jeffrey type *A* hammermill, in closed circuit with the screen, reduces the oversize. Ground shale is stored in a steel bin of 75-ton capacity, and is fed by a Meco disc feeder to a J. C. Steele No. 200E pug mill. Extrusion is by a Steele No. 40F combined pug, de-airing, and auger machine. The stream is extruded under a vacuum of 27 inches and is cut by a J. C. Steele No. 18 cutter. Brick are hacked 600 to a car for drying; they are arranged in two 300-brick cubes for subsequent forklift handling.

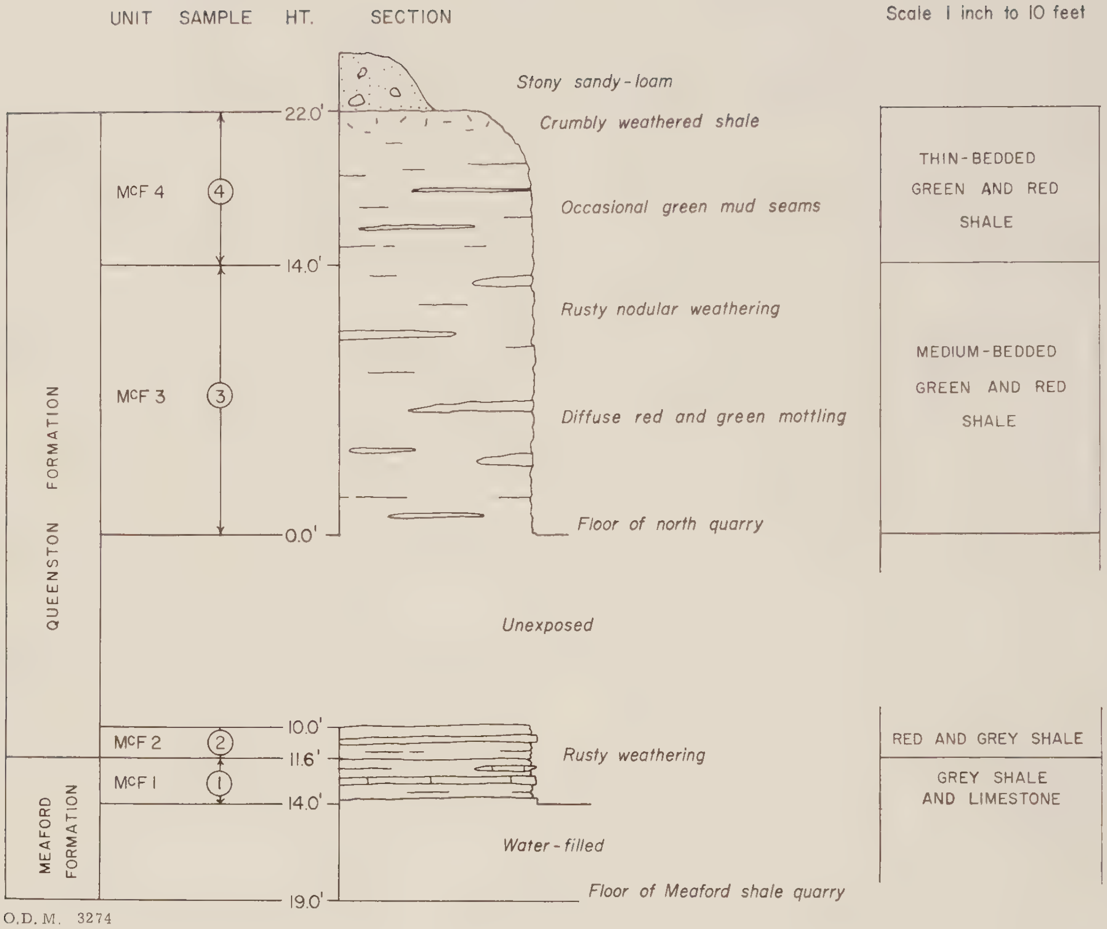
Twelve gas-fired tunnel dryers, 100 feet long, hold 14 cars on each track for a total drying capacity of 100,000 brick. Drying time is about 36 hours. There are 4 rectangular downdraft kilns, 3 of which hold 85,000 brick each and one holds 110,000. The brick are stacked in the kilns by forklift. Firing is by natural gas but fuel oil is available as a stand-by. Draught is provided by a 36-inch Meco exhaust fan. The firing cycle is 115–120 hours and the peak temperatures are 2000°F–2075°F. The kilns are turned over on 11-day cycles at peak production.

Finished brick are stacked in cubes of 500 and shipped by truck from yard storage.

GEOLOGY

Three quarries have been cut into a low easterly facing scarp of Queenston shale; in each case the working faces are several hundred feet long. One quarry consists of 8–10 feet of soft weathered surface shale. Another, with a 15-foot face, is a red-burning shale. The most northerly quarry has a 20-foot face of variegated red and green shale that is also red-burning, but with the addition of limestone makes an attractive buff brick. The face of this quarry is illustrated in figure 17 and described in tables 63, 64, and 65.

Floors of the two main quarries are 10–15 feet above the contact with the grey Meaford shale. East of the main quarries a small water-filled pit exposes the Meaford-Queenston contact. The results of chemical, mineralogical, and ceramic testing of chip samples of the Queenston and Meaford shales are given in tables 63, 64, and 65.


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 10 feet
Stony sandy-loam
22.0'
Crumbly weathered shale
McF 4
④
Occasional green mud seams
THIN-BEDDED GREEN AND RED SHALE
14.0'
Rusty nodular weathering
McF 3
③
Diffuse red and green mottling
MEDIUM-BEDDED GREEN AND RED SHALE
QUEENSTON FORMATION
0.0'
Floor of north quarry
Unexposed
10.0'
McF 2
②
11.6'
Rusty weathering
RED AND GREY SHALE
McF 1
①
14.0'
GREY SHALE AND LIMESTONE
MEAFORD FORMATION
Water-filled
19.0'
Floor of Meaford shale quarry
O.D.M. 3274

Unit		Thickness (*feet*)
McF 4	SHALE: Mottled green and red; moderately hard; thin-bedded; upper 4 feet weathered soft and crumbly; occasional very thin interbeds of soft green mud.	8.0
McF 3	SHALE: Mottled green and red; hard; medium-bedded; nodular rusty weathering; about 25 percent diffuse green beds.	14.0
McF 2	SHALE: Interlayered red and grey; soft to hard; laminated; rusty weathering; several interbeds of very thin, buff, rusty weathering, hard shaly limestone.	1.6
McF 1	SHALE AND LIMESTONE: Interlayered soft grey shale and hard grey-green limestone; very thin-bedded to finely laminated; shales occasionally mottled red and rusty.	2.4

Figure 17—F. B. McFarren Ltd., quarry section.

TABLE 64 Mineral Analyses: F. B. McFarren, Limited
(A = abundant; B = moderate; D = trace; ND = not detected)

Sample	1	2	3	4	Composite
Height above floor (*feet*)	−14.0 to −11.6	−11.6 to −10.0	0.0–14.0	14.0–22.0	0.0–22.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals					
Quartz	32	26	23	23	27
Calcite	12	11	12	5	10
Dolomite	ND	ND	ND	ND	ND
Soda-lime feldspar	2	<0.5	6	2	3
Potash feldspar	ND	<0.5	ND	<0.5	<0.5
Clay minerals					
Illite	A	A	A	A	A
Chlorite	B	B	B	B	B
Expanding minerals	ND	ND	D*	D*	D*

*Vermiculite.

TABLE 65 Ceramic Tests: F. B. McFarren, Limited

SAMPLE 1: Meaford shale: −14.0′ to −11.6′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	2.6
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.3	0.7	0.1
Colour	light brown	pink-brown	medium-brown
Hardness	almost hard	hard	hard
24-hour absorption (%)		15.2	12.6
5-hour boil absorption (%)		18.1	16.0
Specific gravity		1.82	1.84

REMARKS: Briquettes fired at cone 010 disintegrated due to slaking of lime fragments. Briquettes are slightly blistered at cone 03.

SAMPLE 2: Queenston shale: −11.6′ to −10.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	3.6
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3 (expansion)	0.7
Colour	salmon	salmon-pink	pink-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	16.0	14.8	10.5
5-hour boil absorption (%)	17.8	18.0	15.0
Specific gravity	1.82	1.81	1.87

REMARKS: Briquettes are slightly blistered at cone 03.

SAMPLE 3: Queenston shale: 0.0′–14.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.5
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2 (expansion)	0.2 (expansion)	0.5
Colour	salmon	salmon-red	red-brown
Hardness	almost hard	hard	hard
24-hour absorption (%)	13.6	12.7	9.8
5-hour boil absorption (%)	15.3	15.6	13.4
Specific gravity	1.90	1.89	1.93

SAMPLE 4: Queenston shale: 14.0′–22.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	3.8
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3	0.9	2.8
Colour	salmon	red	red-brown
Hardness	hard	hard	very hard
24-hour absorption (%)	12.1	10.2	6.0
5-hour boil absorption (%)	13.5	13.0	9.3
Specific gravity	1.92	1.96	2.07

REMARKS: All are smooth-textured attractive briquettes.

MILTON BRICK COMPANY LIMITED

The plant of the Milton Brick Company Limited is located beside the C.P.R. line 2 miles west of Milton. The shale quarry is at the base of the Niagara escarpment just across the township line, west of the plant, in lot 1, concession I, Esquesing township, Halton county. Sales are handled from the head office at 76 St. Clair Avenue West, Toronto. Early references to the Milton Brick Company are contained in reports by Baker (1906, p. 68–69), Keele (1924, p. 22), and Montgomery (1930, p. 121).

TABLE 66 Partial Chemical Analyses: Milton Brick Company Limited

Sample	1	2	3	4	5
Height above floor (*feet*)	0.0–17.0	17.0–28.5	28.5–42.0	42.0–56.7	56.7–66.7
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Fe_2O_3	6.63	6.05	6.53	6.22	6.62
CaO	7.62	8.15	6.20	7.02	8.27
Loss on ignition	11.04	10.96	9.76	10.85	10.89
Soluble salts	0.64	0.72	0.85	0.54	0.56

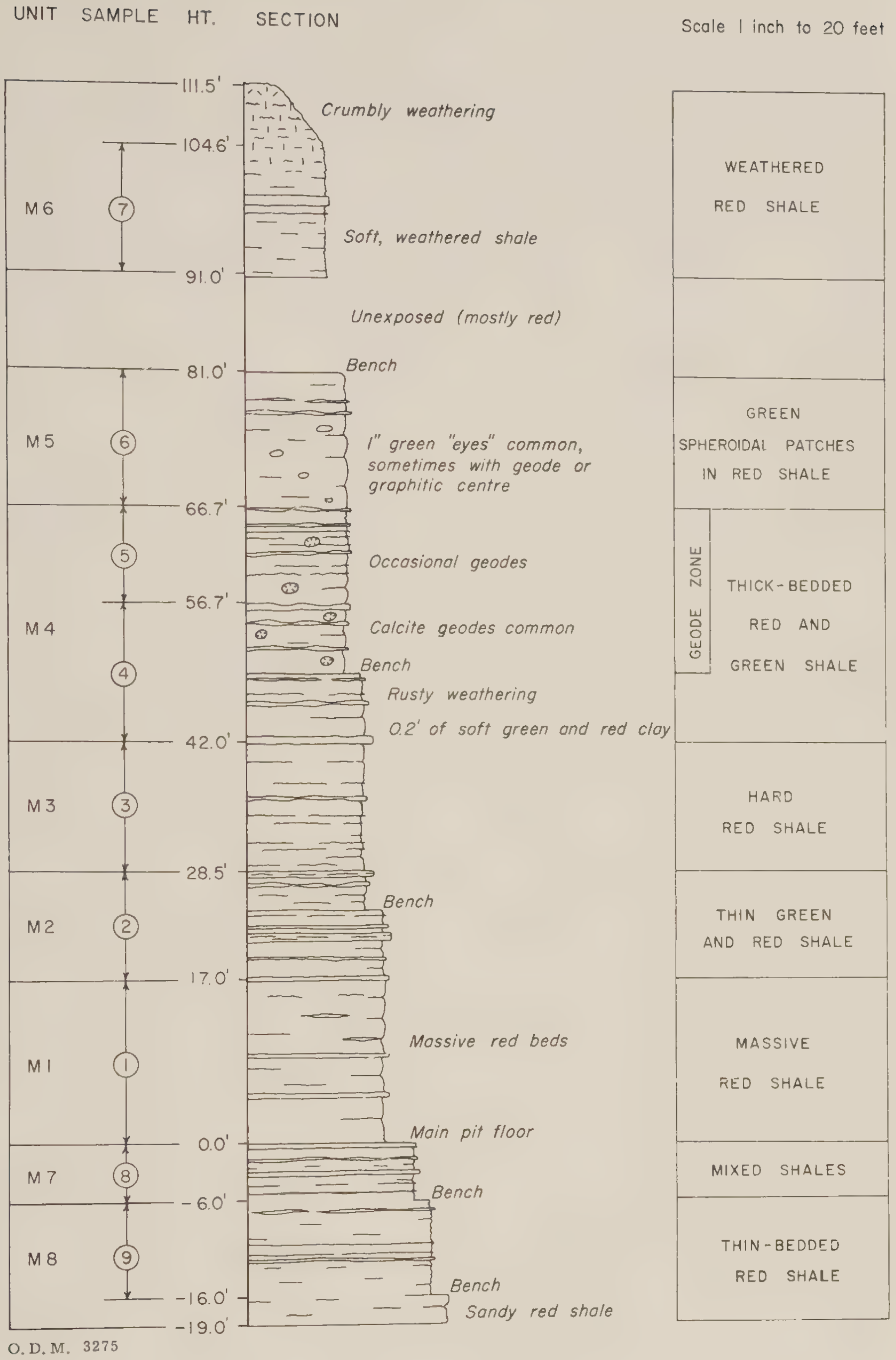
TABLE 67 Chemical Analyses: Milton Brick Company Limited

Sample	6	7	8	9	Composite
Height above floor (*feet*)	66.7–81.0	91.0–104.6	0.0 to −6.0	−6.0 to −16.0	−16.0 to 104.6
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2					50.91
Al_2O_3					14.9
Fe_2O_3	6.40	6.57	4.62	6.67	6.53
CaO	7.52	4.84	10.9	6.57	7.41
MgO					4.40
Na_2O					0.36
K_2O					4.02
TiO_2					0.73
CO_2					6.67
H_2O+ (combined)					2.93
H_2O- (moisture)					0.82
SO_3					0.27
TOTAL					100.0
Loss on ignition	12.18	9.36	12.94	9.74	10.62
Soluble salts	0.56	0.40	0.55	0.58	

TABLE 68 Mineral Analyses: Milton Brick Company Limited
(A = abundant; B = moderate; D = trace; ND = not detected)

	1	2	3	4	5	6	7	8	9	Composite
Height above floor (*feet*)	0.0–17.0	17.0–28.5	28.5–42.0	42.0–56.7	56.7–66.7	66.7–81.0	91.0–104.6	0.0 to −6.0	−6.0 to −16.0	−16.0 to 104.6
	(*percent*)	(*percent*)	*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*))	(*percent*)
Non-clay minerals										
Quartz	23	23	28	25	18	23	22	21	24	24
Calcite	10	11	9	9	7	8	2	16	5	10
Dolomite	<0.5	3	2	4	4	4	8	2	2	4
Soda-lime feldspar	ND	ND	ND	<0.5	ND	<0.5	ND	<0.5	ND	<0.5
Potash feldspar	ND	ND	ND	ND	ND	<0.5	ND	ND	ND	<0.5
Amphibole		<1								
Clay minerals										
Illite	A	A	A	A	A	A	A	A	A	A
Chlorite	B	B	B	B	B	B	B	B	B	B
Expanding minerals	ND	ND	ND	ND	ND	ND	ND	D*	D*	ND

*Vermiculite.


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 20 feet
111.5'
104.6'
91.0'
81.0'
66.7'
56.7'
42.0'
28.5'
17.0'
0.0'
- 6.0'
-16.0'
-19.0'
M 6
M 5
M 4
M 3
M 2
M 1
M 7
M 8
7
6
5
4
3
2
1
8
9
Crumbly weathering
Soft, weathered shale
Unexposed (mostly red)
Bench
1" green "eyes" common, sometimes with geode or graphitic centre
Occasional geodes
Calcite geodes common
Bench
Rusty weathering
0.2' of soft green and red clay
Bench
Massive red beds
Main pit floor
Bench
Bench
Sandy red shale
WEATHERED RED SHALE
GREEN SPHEROIDAL PATCHES IN RED SHALE
GEODE ZONE
THICK-BEDDED RED AND GREEN SHALE
HARD RED SHALE
THIN GREEN AND RED SHALE
MASSIVE RED SHALE
MIXED SHALES
THIN-BEDDED RED SHALE
O.D.M. 3275

Unit		Thickness (*feet*)
M 6	Shale: Mostly red; soft; thin-bedded; deeply weathered.	20.5
M 5	Shale: Red with rare mottled green lenses; moderately hard; thick to massive-bedded; 1-inch green "eyes" (spherulites) with geodes or graphitic cores common; rusty weathering.	14.3
M 4	Shale: Red with a few green beds; hard; medium and thick-bedded; small calcite geodes common; some rusty nodular weathering.	24.7
M 3	Shale: Red with a few green lenses; very hard; thick-bedded; some rusty weathering.	13.5
M 2	Shale: Mixed green and red; hard; thin-bedded.	11.5
M 1	Shale: Red with occasional green patches and lenses; moderately hard; thick to massive bedded; nodular weathering.	17.0
M 7	Shale: Mixed green and red; hard; thin to medium-bedded.	6.0
M 8	Shale: Red with a few green lenses and patches; moderate hardness; thin-bedded.	13.0

Figure 18—Milton Brick Co. Ltd., quarry section.

TABLE 69 Ceramic Tests: Milton Brick Company Limited

SAMPLE 1: 0.0′–17.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.9
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2 (expansion)	0.2 (expansion)	1.0
Colour	orange-red	salmon-pink	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	11.4	10.5	5.3
5-hour boil absorption (%)	13.0	13.1	7.9
Specific gravity	1.91	1.90	1.94

REMARKS: Briquettes are slightly blistered at cone 03.

SAMPLE 2: 17.0′–28.5′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.2
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3 (expansion)	0.2 (expansion)	0.3
Colour	salmon-pink	salmon-pink	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	12.1	10.9	5.8
5-hour boil absorption (%)	13.7	13.8	8.6
Specific gravity	1.89	1.89	1.95

REMARKS: Briquettes are slightly overfired at cone 03.

SAMPLE 3: 28.5′–42.0′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	2.9
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3	1.7
Colour	orange-red	orange-red	brown
Hardness	hard	very hard	very hard
24-hour absorption (%)	10.9	8.7	3.0
5-hour boil absorption (%)	12.2	11.2	4.0
Specific gravity	1.95	1.97	2.04

REMARKS: Briquettes are overfired at cone 03.

SAMPLE 4: 42.0′–56.7′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.8
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.2 (expansion)	0.3
Colour	salmon	salmon	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	11.8	10.4	5.1
5-hour boil absorption (%)	13.3	13.1	7.8
Specific gravity	1.92	1.91	1.95

REMARKS: Briquettes are overfired at cone 03.

SAMPLE 5: 56.7′–66.7′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.6
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	1.0
Colour	salmon	salmon	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	11.7	10.6	3.9
5-hour boil absorption (%)	13.2	13.2	6.1
Specific gravity	1.92	1.92	1.99

REMARKS: Briquettes are overfired but undeformed at cone 03.

SAMPLE 6: 66.7′–81.0′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	3.2
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	0.9
Colour	salmon	salmon	brown
Hardness	hard	hard	very hard
24-hour absorption (%)	12.2	11.2	2.7
5-hour boil absorption (%)	14.1	14.2	4.3
Specific gravity	1.89	1.89	1.99

REMARKS: Briquettes are overfired but undeformed at cone 03.

TABLE 69 (*continued*)

SAMPLE 7: 91.0′–104.6′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.0
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.2	4.0	5.9
Colour	salmon	red	brown
Hardness	almost hard	very hard	very hard
24-hour absorption (%)	12.2	6.6	1.7
5-hour boil absorption (%)	13.5	8.2	1.9
Specific gravity	1.93	2.09	2.25

REMARKS: All are uniform, smooth-textured, attractive briquettes

SAMPLE 8: 0.0′–6.0′

Water of plasticity (*percent*)	15
Lineal drying shrinkage (*percent*)	2.1
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.2	1.0	0.7
Colour	light salmon	pink-tan	dark-buff
Hardness	almost hard	almost hard	hard
24-hour absorption (%)	14.5	13.4	11.0
5-hour boil absorption (%)	16.2	16.8	16.1
Specific gravity	1.83	1.80	1.80

SAMPLE 9: −6.0′ to −16.0′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	3.1
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2	0.8	1.5
Colour	salmon	salmon-red	red-brown
Hardness	hard	hard	very hard
24-hour absorption (%)	11.9	10.2	5.9
5-hour boil absorption (%)	13.3	12.4	8.6
Specific gravity	1.92	1.95	2.00

Plant

Productive capacity is rated at 30 million brick annually. Brick are produced in a full range of colours and textures in Ontario, American, and Modular sizes. About 40 men are employed in the plant.

Some 4 feet of sandy loam overburden is stripped by bulldozer. The main shale production is from three 30-foot benches which are progressing westerly into the escarpment. A small quarry a few hundred feet west of the plant is worked in two benches. The shale is drilled with a 5-foot spacing and burden using a wagon-type drill. Holes are 2½ inches in diameter and 30 feet deep. Sections are blasted well in advance to take advantage of the benefits of natural weathering. Two ¾-yard diesel shovels, a Thew and a Koering No. 304, operate in the main quarry and load two 5-yard dump trucks for the ¼-mile haul to the plant. A ¾-yard Bucyrus Erie shovel is used in the smaller quarry.

The shale is dumped directly into a feed hopper ahead of the primary crusher. This is a single-toothed roll of 48-inch width which reduces the feed to minus 4-inch. Fine grinding is accomplished by a 10-foot Clearfield drypan. There are three 4-foot by 7-foot, electrically-heated, vibrating, Leahy screens in closed circuit with a Miller hammermill. The minus 12-mesh shale is stored in 2 brick silos having a total capacity of 450 tons. Two brick circuits are supplied by feeders beneath the silos. The Steele combined pug, de-airing, and auger machines are each preceded by Steele pug mills. About 18 percent water is added for tempering, and de-airing is accomplished at a vacuum of 27 inches. Brick are produced at the rate of 12,000 and 7,000 per hour by the two lines. They are finished in one of four textures—smooth, matex, rug, or bark—and are cut by Steele No. 17 cutters. They are hacked on cars of two sizes, either 900 or 1,800 brick per car.

The brick are dried in the front portions of 3 tunnel kilns. These are each 425 feet long and hold 50 cars. They are gas-fired to peak temperatures of 1950°F (red brick) or 2000°F (buff brick). Total drying and firing time is 60 hours.

ODM7449

Photo 25—Milton Brick Company Limited; shale quarry 1965.

Some shed storage and loading facilities are available at one end of the plant. Shipments are made by truck or rail.

GEOLOGY

A 130-foot section of Queenston shale is exposed in the main quarry. The upper 110 feet are worked in three benches, with working faces about 600 feet long; the shale contains less than 10 percent green lenses and burns to a light red colour. A 6-foot section immediately below the main quarry floor consists of 25 percent green shale and burns to a dark buff colour. A 10-foot section of red shale below the buff-burning shale is used mainly for pressed brick; it burns to a dark red colour. The complete section is illustrated in figure 18 and described in the accompanying tables. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 66, 67, 68, and 69.

A 20-foot section of Queenston shale is worked across a 200-foot face in a second quarry 300 yards southeast of the main quarry. Stratigraphically the section corresponds to a zone in the vicinity of the floor of the main quarry. The shale is predominantly red, thin and medium-bedded, and rusty weathering.

CUNNINGHAM, REID 23745

Photo 26—Natco Clay Products Limited; plant 1960. (Photo by Cunningham and Reid Ltd., Hamilton.)

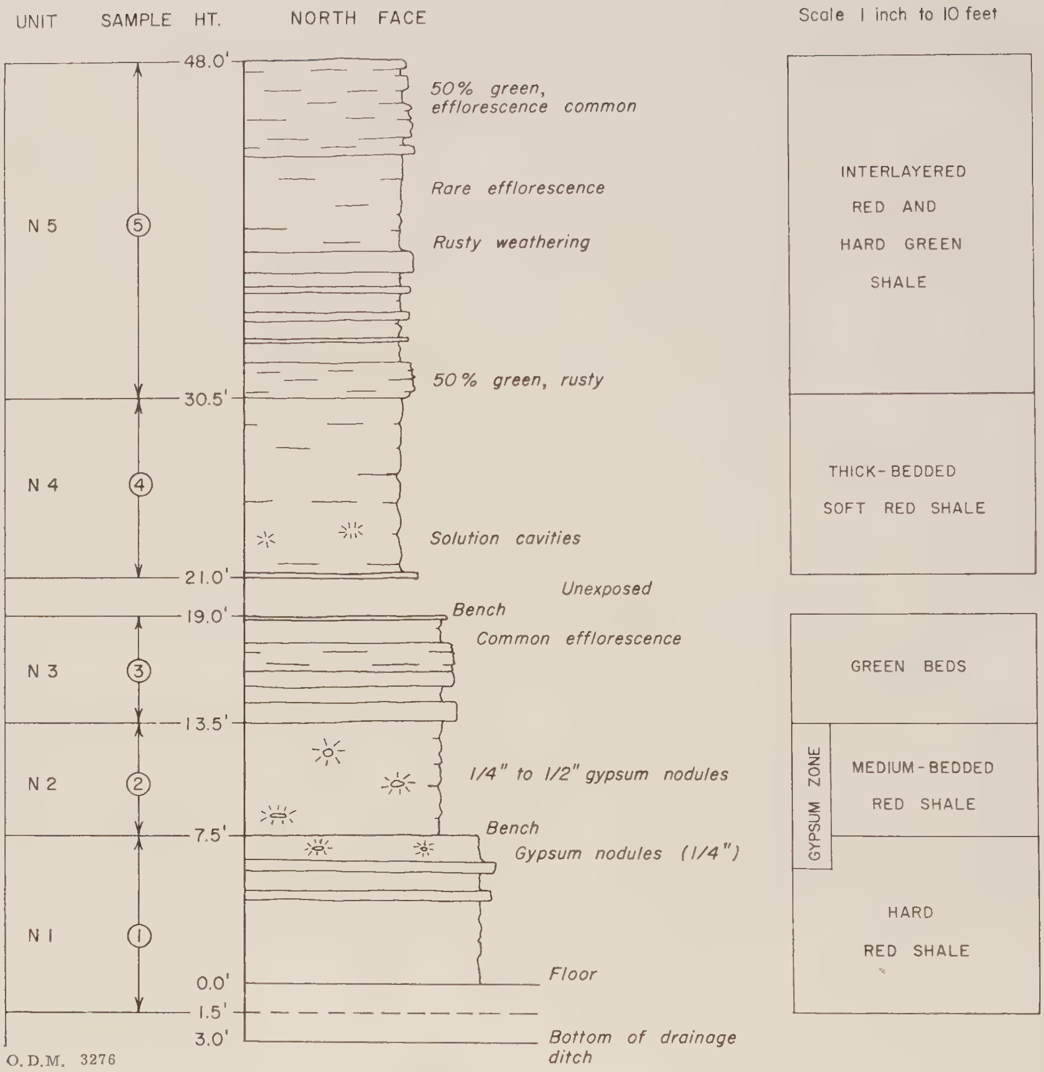
NATCO CLAY PRODUCTS LIMITED

A wide range of structural tile is manufactured at the Aldershot plant of Natco Clay Products Limited. The plant is located on the C.N.R. Toronto-Hamilton line in lot 10, concession I, East Flamboro township, Wentworth county. It was built in 1910 and was operated until 1954 under the name of National Fireproofing Company of Canada. Early references to this company are contained in reports by Keele (1924, p. 96) and Montgomery (1930, p. 158).

Plant

Some 40,000 tons of finished ware are manufactured yearly. About 50 different sizes and shapes—predominantly drain, structural, partition, and fireproofing tile—are made, and about half this number are in common production. The operation employs 50 men in the plant on a continuous basis.

In the early years red Aldershot clay alone was used, but because of limited reserves it was subsequently mixed 1:3 with Queenston shale. With the final exhaustion of the clay in 1953, production was carried for a few years on a soft weathered surface shale trucked from a quarry in the Milton district. Queenston shale is presently being obtained from a quarry near Aldershot, but the Natco quarry may again be used as it still contains attractive reserves of shale. A year's supply is stockpiled at the plant during the summer months. It is reclaimed by a


UNIT
SAMPLE
HT.
NORTH FACE
Scale 1 inch to 10 feet
48.0'
30.5'
21.0'
19.0'
13.5'
7.5'
0.0'
1.5'
3.0'
N 5
N 4
N 3
N 2
N 1
⑤
④
③
②
①
50% green, efflorescence common
Rare efflorescence
Rusty weathering
50% green, rusty
Solution cavities
Unexposed
Bench
Common efflorescence
1/4" to 1/2" gypsum nodules
Bench
Gypsum nodules (1/4")
Floor
Bottom of drainage ditch
INTERLAYERED RED AND HARD GREEN SHALE
THICK-BEDDED SOFT RED SHALE
GREEN BEDS
MEDIUM-BEDDED RED SHALE
GYPSUM ZONE
HARD RED SHALE
O.D.M. 3276

Unit		Thickness (*feet*)
N 5	SHALE: Soft red shale interlayered with discreet hard green beds; thin and medium-bedded; some rusty weathering; efflorescence in upper part of section.	17.5
N 4	SHALE: Red with a few thin green lenses; moderately soft; medium- to thick-bedded; coarse nodular weathering.	9.5
N 3	SHALE: Green, with 40 percent red and mottled shale; moderately soft to hard; thin and medium-bedded; moderate efflorescence.	5.5
N 2	SHALE: Mostly red; moderately hard; medium-bedded; nodular weathering; a few small gypsum nodules.	6.0
N 1	SHALE: Red with several discreet green beds; moderately hard; medium-bedded; tough platy parting; a few small gypsum nodules in upper part of section.	9.0

Figure 19—Natco Clay Products Ltd., quarry section.

TABLE 70 Chemical Analyses: Natco Clay Products Limited

Sample	1	2	3	4	5	Composite
Height above floor (*feet*)	−1.5 to 7.5	7.5–13.5	13.5–19.0	21.0–30.5	30.5–48.0	−1.5 to 48.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2						49.67
Al_2O_3						14.3
Fe_2O_3	5.85	6.47	4.73	6.65	5.88	6.27
CaO	9.17	8.58	15.1	7.73	10.3	10.2
MgO						3.15
Na_2O						0.58
K_2O						3.64
TiO_2						0.76
CO_2						8.64
H_2O+ (combined)						2.42
H_2O- (moisture)						0.87
SO_3						0.28
TOTAL						100.8
Loss on ignition	11.54	11.10	15.18	10.52	11.96	12.23
Soluble salts	0.67	0.72	0.50	0.78	0.45	

TABLE 71 Mineral Analyses: Natco Clay Products Limited
(A = abundant; B = moderate; D = trace; ND = not detected)

Sample	1	2	3	4	5	Composite
Height above floor (*feet*)	−1.5 to 7.5	7.5–13.5	13.5–19.0	21.0–30.5	30.5–48.0	−1.5 to 48.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals						
Quartz	29	22	25	25	28	24
Calcite	15	12	22	10	15	15
Dolomite	2	<0.5	4	<0.5	3	2
Soda-lime feldspar	2	1	<0.5	<0.5	1	1
Potash feldspar	ND	ND	ND	ND	ND	ND
Clay minerals						
Illite	A	A	A	A	A	A
Chlorite	B	B	B	B	B	B
Expanding minerals	ND	D*	ND	ND	ND	ND

*Vermiculite

TABLE 72 Ceramic Tests: Natco Clay Products Limited

SAMPLE 1: −1.5′ to 7.5′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.2
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.3	1.0	0.3
Colour	pink-red	pink-red	light brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)	14.8	13.9	9.8
5-hour boil absorption (%)	16.7	17.7	14.6
Specific gravity	1.81	1.79	1.83

REMARKS: White scum common on all briquettes.

SAMPLE 3: 13.5′–19.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.0
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.7	2.1	1.4
Colour	salmon	pink-buff	tan-buff
Hardness	moderately soft	almost hard	hard
24-hour absorption (%)	19.5	19.0	16.3
5-hour boil absorption (%)	20.4	24.0	23.4
Specific gravity	1.69	1.63	1.64

REMARKS: Briquettes are slightly overfired at cone 03.

SAMPLE 2: 7.5′–13.5′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.6
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3 expansion	0.3 expansion	0.3
Colour	red	red	red-brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)	11.6	11.3	6.4
5-hour boil absorption (%)	13.3	14.0	9.5
Specific gravity	1.90	1.88	1.92

REMARKS: Briquettes fired at cone 03 are slightly blistered and overfired.

SAMPLE 4: 21.0′–30.5′

Water of plasticity (*percent*)	16
Lineal drying shrinkage (*percent*)	2.4
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2 expansion	0.3 expansion	0.3
Colour	red	red	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	12.4	11.7	6.4
5-hour boil absorption (%)	14.0	14.2	9.6
Specific gravity	1.91	1.91	1.95

REMARKS: Briquettes are slightly blistered and overfired at cone 03.

SAMPLE 5: 30.5′–48.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.4
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3 expansion	1.0 expansion	2.2
Colour	salmon-red	pink-buff	yellow-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	16.2	14.8	7.3
5-hour boil absorption (%)	18.1	18.2	11.6
Specific gravity	1.81	1.79	1.93

REMARKS: Briquettes are slightly overfired at cone 03.

¾-yard Dominion diesel shovel which loads a truck for the short haul to the raw material hopper. A D4 Caterpillar 1-yard front-end loader is also available for loading or clean-up work around the plant.

Primary crushing of the shale is accomplished by a 36-inch diameter, 18-inch Stevenson single-roll toothed crusher. The 4-inch crusher discharge is collected in a small surge bin equipped with an automatic vibrating feeder controlled by demand from the grinding circuit. A 10-foot Chambers pneumatic drypan handles the bulk of the grinding, but at times of peak load a 9-foot Berg drypan can also be used. The Chambers pan is in closed circuit with two 4-foot by 10-foot Link Belt 16 mesh screens. Discharge from the Berg pan is screened on a single 16 mesh screen. A small secondary bin and vibrating feeder facilitates blending when required. Ground shale is stored in a steel bin of 60 tons capacity.

Shale from storage feeds an F-R-H double-shaft pug mill. Minor amounts of Lignosol and barium carbonate are added in solution with the tempering water. Natural moisture content of the shale is about 6 percent, and a further 10 percent is added during pugging. Tile are extruded by an F-R-H, type WJ, extruder. It extrudes 25 to 30 tons of ware per hour under a vacuum of 25 inches. A manually operated cutter is necessitated by the many sizes and shapes of manufactured ware. The tile are hacked at the rate of about 1 ton per car.

A 16-track tunnel dryer 100 feet long can accommodate 14 cars on each track. A room dryer, 16 tracks wide and 75 feet long, holds 10 cars on each track. Sufficient waste heat is available for about one-third of the drying requirement; the rest is obtained by burning gas. Drying time is about 48 hours at a temperature of 210°F. There are 8 beehive kilns of 32-foot diameters, 1 of 28 feet, and 1 of 36 feet. A 160-foot stack provides natural draft for 7 of the kilns. Natural gas is burned in 1 kiln, bunker oil in the others, and the peak firing temperature is about 1800°F. Kiln capacity averages 90–100 tons each and the turnover cycle is 9 or 10 days.

Burned tile are stocked mostly in the yard but a limited amount of shed storage is also available. Much of the ware is palletized in 1-ton units for truck shipment.

GEOLOGY

Reserves of red Aldershot clay have been exhausted on the Natco property. The clay, which was derived from eroding hills of Queenston shale to the north, had been deposited in a shallow lagoon separated from Lake Iroquois by the Aldershot gravel bar. Remnants at the eastern end of the same clay bed are still being recovered by National Sewer Pipe Limited north of Aldershot.

A 50-foot section of Queenston shale is exposed in a quarry on the west side of the Natco plant and south of the C.N.R. tracks. The shale was formerly mixed with the red surface clay until reserves of the latter were exhausted in 1953. Soft weathered Queenston shale from a quarry at Milton replaced the clay addition in the plant feed for 5 years, but since 1958 Queenston shale from an Aldershot source has been used exclusively.

The Natco quarry adjacent to the plant is about 400 by 1,000 feet. The workings have progressed from a ravine on the south side to the C.N.R. tracks that form the north limit of the quarry. The upper one-third of the 50-foot shale section forms the embankment for the tracks over most of the long side of the quarry; no further reserves of this portion of the shale section are available in the quarry area. The lower 30 feet of the shale section has been worked in three benches, and substantial reserves of this shale are available.

A geological section of the Natco quarry is illustrated in figure 19. Description of the shale units, and the results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 70, 71, and 72.

NATIONAL SEWER PIPE LIMITED, WATERDOWN QUARRIES

National Sewer Pipe Limited operates several quarries for Queenston shale on the east side of King Road in lots 1 and 2, concession II, East Flamboro township, Wentworth county. The quarries are located in an area of bare eroded hills of the Queenston Formation, on a gently sloping face of the Niagara escarpment two miles east of Waterdown. A number of small openings have been made in the shale throughout the 400 acres owned by the company, and much of the soft weathered shale has been scraped from the eroding surfaces and intervening

Table 73 Chemical Analyses: National Sewer Pipe Limited

	South Quarry			North Quarry		
Sample	1	2	3	4	5	Both quarries Composite
Height above floor (*feet*)	0.0–9.0	9.0–20.7	20.7–31.0	0.0–14.0	14.0–31.0	
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2						52.02
Al_2O_3						14.5
Fe_2O_3	6.97	5.63	7.08	7.28	6.68	6.57
CaO	7.00	9.35	6.15	5.15	6.98	6.81
MgO						3.75
Na_2O						0.32
K_2O						4.12
TiO_2						0.76
CO_2						5.88
H_2O+						2.91
H_2O-						0.99
SO_3						0.28
TOTAL						98.7
Loss on ignition	9.86	12.00	9.72	9.12	10.54	10.08
Soluble salts	0.64	0.76	0.34	0.46	0.69	

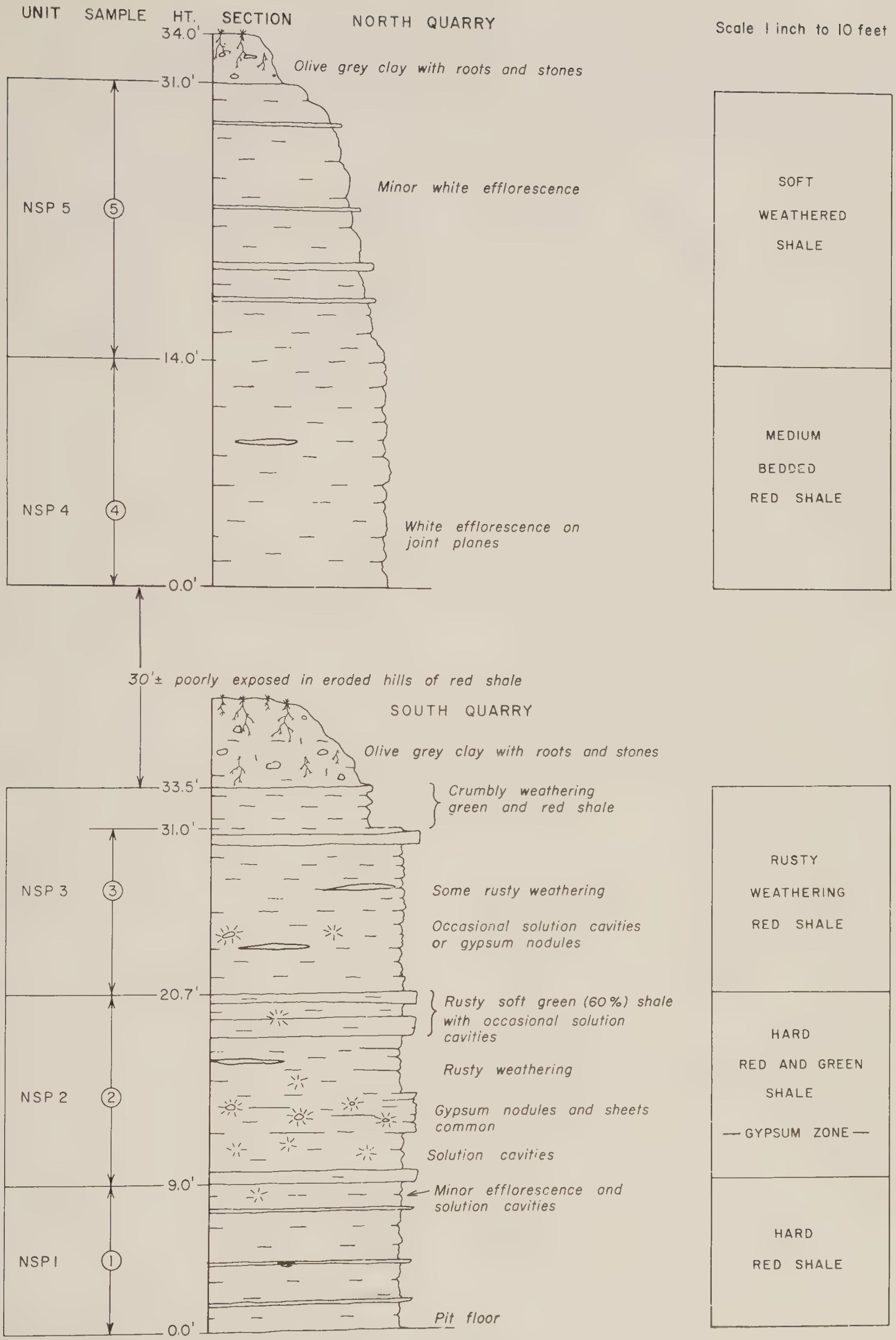
Table 74 Mineral Analyses: National Sewer Pipe Limited
(A = abundant; B = moderate; C = minor; D = trace; ND = not detected)

	South Quarry			North Quarry		
Sample	1	2	3	4	5	Both quarries Composite
Height above floor (*feet*)	0.0–9.0	9.0–20.7	20.7–31.0	0.0–14.0	14.0–31.0	
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals						
Quartz	25	27	26	28	30	28
Calcite	8	13	8	4	10	10
Dolomite	3	4	<0.5	2	2	2
Soda-lime feldspar	ND	ND	<0.5	ND	ND	<0.5
Potash feldspar	ND	ND	<0.5	ND	ND	ND
Clay minerals						
Illite	A	A	A	A	A	A
Chlorite	B	B	B	B	B	B
Expanding minerals	ND	D*	D*	C*	ND	ND

*Vermiculite.

Description of Waterdown quarry sections, National Sewer Pipe Ltd. (figure 20.)

Unit		Thickness (*feet*)
OVERBURDEN:	Olive-grey till, drying yellow-grey; silty and stony; roots common.	
NSP 5	SHALE: Red with a few green lenses; soft due to weathering; thick-bedded; minor efflorescence.	17.0
NSP 4	SHALE: Red with rare green lenses; uniform; moderately soft; medium-bedded; efflorescence locally heavy on joint planes in lower part of section.	14.0
NSP 3	SHALE: Red with rare green lenses; thin- to medium-bedded; rusty weathering on joints and fractures; rare small solution cavities and gypsum nodules.	12.8
NSP 2	SHALE: Red with numerous green layers or lenses; rather hard; medium-bedded; ½-inch nodules and 1/16-inch sheets of gypsum are common; solution cavities common; some rusty weathering.	11.7
NSP 1	SHALE: Red with a few thin green layers; hard; thick-bedded; minor rusting; efflorescence, and solution cavities near top of section.	9.0


UNIT
SAMPLE
HT.
SECTION
NORTH QUARRY
Scale 1 inch to 10 feet
34.0'
31.0'
14.0'
0.0'
NSP 5
⑤
NSP 4
④
Olive grey clay with roots and stones
Minor white efflorescence
White efflorescence on joint planes
SOFT WEATHERED SHALE
MEDIUM BEDDED RED SHALE
30'± poorly exposed in eroded hills of red shale
SOUTH QUARRY
Olive grey clay with roots and stones
33.5'
31.0'
20.7'
9.0'
0.0'
Crumbly weathering green and red shale
NSP 3
③
Some rusty weathering
Occasional solution cavities or gypsum nodules
NSP 2
②
Rusty soft green (60%) shale with occasional solution cavities
Rusty weathering
Gypsum nodules and sheets common
Solution cavities
Minor efflorescence and solution cavities
NSP 1
①
Pit floor
RUSTY WEATHERING RED SHALE
HARD RED AND GREEN SHALE
— GYPSUM ZONE —
HARD RED SHALE

O.D.M. 3277

Figure 20—National Sewer Pipe Ltd., Waterdown quarry sections.

TABLE 75 Ceramic Tests: National Sewer Pipe Limited

SAMPLE 1: South quarry 0.0′–9.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	2.6
Pyrometric cone equivalent	8

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2	0.5	2.1
Colour	red	red-brown	dark brown
Hardness	hard	hard	very hard
24-hour absorption (%)	11.7	10.1	1.0
5-hour boil absorption (%)	13.3	12.3	1.4
Specific gravity	1.94	1.95	2.04

REMARKS: Briquettes are overfired but undeformed at cone 03.

SAMPLE 2: South quarry 9.0′–20.7′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	3.7
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7 (expansion)	0.5 (expansion)	3.3
Colour	salmon	pink-brown	green-brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)	14.9	14.2	6.1
5-hour boil absorption (%)	17.2	17.4	9.8
Specific gravity	1.81	1.80	1.91

REMARKS: Briquettes are marked by white scum. At cone 03 they are slightly overfired.

SAMPLE 3: South quarry 20.7′–31.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	3.3
Pyrometric cone equivalent	4

	Cones		
	(1660°F)	(1840°F)	(1980°F)
Lineal firing shrinkage (%)	0.5	1.2	4.5
Colour	red	brown-red	dark brown
Hardness	hard	very hard	very hard
24-hour absorption (%)	12.2	10.0	2.3
5-hour boil absorption (%)	13.9	12.6	3.4
Specific gravity	1.91	1.97	2.18

REMARKS: Briquettes are undeformed but overfired at cone 03.

SAMPLE 4: North quarry 0.0′–14.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.0
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3	1.5	5.0
Colour	orange-red	brown-red	dark brown
Hardness	moderately soft	hard	very hard
24-hour absorption (%)	13.4	10.6	3.0
5-hour boil absorption (%)	15.1	13.2	4.2
Specific gravity	1.86	1.94	2.18

REMARKS: Briquettes are undeformed but overfired at cone 03.

SAMPLE 5: North quarry 14.0′–31.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	3.2
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.7	3.3
Colour	salmon-red	brown-red	brown
Hardness	almost hard	very hard	very hard
24-hour absorption (%)	13.0	11.2	4.8
5-hour boil absorption (%)	14.8	14.4	6.8
Specific gravity	1.86	1.89	2.07

REMARKS: Briquettes are undeformed but overfired at cone 03.

gullies. The company does not use the shale in its Clarkson and Hamilton plants, but it provides all or part of the shale requirements of four other brick and tile plants. Red Aldershot clay, derived from eroding Queenston shale, is blended with imported fireclay for sewer pipe manufacture. The red clay, and the Hamilton and Clarkson plants of National Sewer Pipe Limited, are described in the Clay section of this report.

The main shale quarry is worked in a single 35-foot face, 200 feet long. Excavation is accomplished without blasting, using a 1½-yard Lorain diesel shovel equipped with interchangeable bucket and toothed ripper. A 2½-yard Allis-Chalmers front-end loader assists the shovel in loading and clean-up work. Haulage of the shale is by contract.

A second quarry 1,000 feet northwest of the first has a 30-foot face. Stratigraphically the floor of the second quarry is about 30 feet above the top of the main quarry. Geological sections of the two quarries are illustrated in figure 20. Descriptions of the shale units, and the results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 73, 74, and 75.

ST. CATHARINES BRICK AND TILE COMPANY, LIMITED

The plant of St. Catharines Brick and Tile Company, Limited is located on Herrick Avenue, in the south-central part of St. Catharines. The plant was

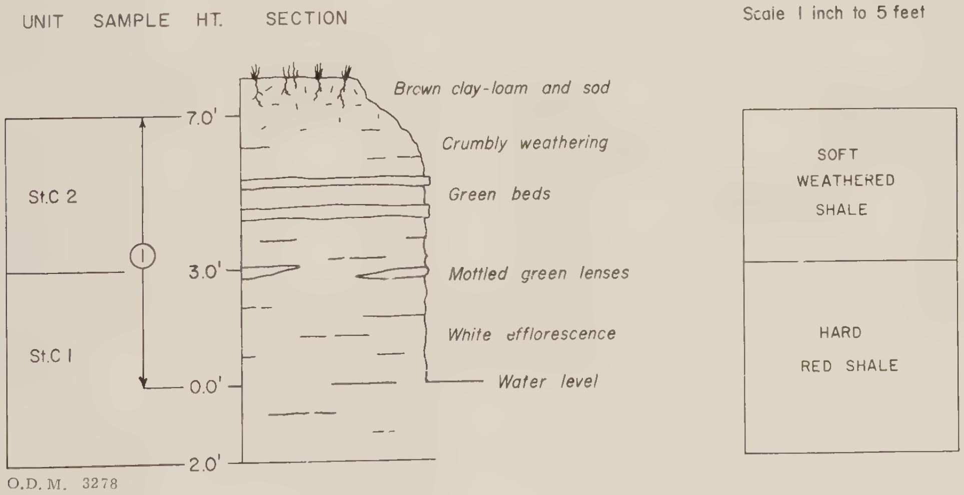
TABLE 76 Partial Chemical Analysis:
St. Catharines Brick and Tile Company, Limited

Sample	1
Height above floor (*feet*)	0.0–7.0
	(*percent*)
Fe_2O_3	6.78
CaO	3.43
Loss on ignition	7.14
Soluble salts	0.56

TABLE 77 Mineral Analysis:
St. Catharines Brick and Tile Company, Limited
(A = abundant; C = minor; D = trace;
ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–7.0
	(*percent*)
Non-clay minerals	
Quartz	27
Calcite	3
Dolomite	ND
Soda-lime feldspar	1
Potash feldspar	ND
Clay minerals	
Illite	A
Chlorite	C
Expanding minerals	D*

*Vermiculite



Unit		Thickness (*feet*)
St.C 2	SHALE: Red with two prominent continuous green beds; very soft; medium-bedded; crumbly weathering.	4.0
St.C 1	SHALE: Red; rather hard; medium- to thick-bedded; some white efflorescence near base of section; nodular to blocky weathering.	5.0

Figure 21–St. Catharines Brick and Tile Co. Ltd., quarry section.

TABLE 78 Ceramic Tests:
St. Catharines Brick and Tile Company, Limited

SAMPLE 1: 0.0′–7.0′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	3.6
Pyrometric cone equivalent	5–6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3	2.3	4.9
Colour	salmon	salmon-red	red-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	12.0	8.5	3.2
5-hour boil absorption (%)	13.4	10.3	4.5
Specific gravity	1.95	2.05	2.26

REMARKS: Fired briquettes are marked by a trace of scum. Briquettes fired to cone 03 are slightly blistered and overfired.

built in 1903 and produced soft-mud brick for many years under the management of F. R. Paxton. A deeply weathered Queenston shale is trucked 6 miles from the vicinity of St. Davids. Early references to brick-making at this location are given by Keele (1924, p. 92) and Montgomery (1930, p. 135).

Plant

The capacity of the plant is rated at 10 million brick annually. About half of the production is divided between Roman and Norman sizes; the rest are the usual "Ontario" variety. Brick can be finished in the normal ranges of texture and colour, including flashed colours. The plant employs 30 men on a year-round basis.

The soft weathered surface shale is removed to a depth of 5 to 8 feet and trucked 6 miles to the plant. An enclosed shale storage area with a capacity of 7,000 tons permits continuous plant operation through the winter months. A Hough Payloader reclaims the shale from storage and delivers it to the apron in front of a 9-foot Raymond drypan. Shale is shovelled into the pan by hand, and as much as 15 percent of limestone is added for buff colours. Minor additives such as barium carbonate are proportioned by feeder. A single 3-foot by 7-foot, electrically heated, vibrating, Leahy screen is in closed circuit with the pan. The minus 14-mesh shale is fed directly to a 10-foot Parkhill pug mill; then to an F-R-H Hummer combined pug, de-airing, auger machine. Brick are produced at the rate of 5,000 per hour, and are cut by an American automatic 21-brick cutter.

Eight tunnel dryers have a total capacity of 140 cars. They are coal-heated to 220°F; drying time is 48 hours. Four rectangular downdraft kilns hold 100,000 brick each. They are coal-fired in the winter, but because of a smoke problem for nearby residents gas is used during the summer. The firing temperature for red brick is 1820°F, for buff brick 1880°F. Turnover time for the kilns is about 12 days.

The brick are palletized in 500-brick cubes and shipped by truck.

GEOLOGY

Shale is obtained from a number of shallow cuts in Niagara township, 2 miles northwest of St. Davids. The cuts are water-filled to a depth of several feet, and occur over an area of 15–20 acres. Quarrying takes place intermittently, as necessary to replenish the plant stockpile.

The geological section is illustrated in figure 21, and described in an accompanying note. The results of chemical, mineralogical, and ceramic testing of a vertical channel sample are given in tables 76, 77, and 78.

TORONTO BRICK COMPANY, LIMITED, MILTON QUARRY

Toronto Brick Company, Limited, operated a Queenston shale quarry in lots 14–15, concession I NS, Trafalgar township, Halton county, ½-mile southwest of Milton. The quarry was opened in 1911 by the Brandon Brick Company, but from 1919 to 1929 their plant and shale quarry were operated by Toronto Brick Company (Montgomery 1930, p. 122). The quarry was re-opened in 1956 as a source of Queenston shale for the Toronto Brick Company's Don Valley plant. Queenston shale has not been used in the Don Valley plant since 1963.

Excavation of the shale was accomplished without blasting, using a 1¼-yard Dominion B425 diesel

Description of Milton quarry section, Toronto Brick Co. Ltd. (figure 22)

Unit		Thickness (*feet*)
OVERBURDEN: Brown clay loam with a few stones		4–8
TM 2	SHALE: Red with occasional green lenses and "eyes"; thick-bedded; moderate rusty weathering; small solution cavities locally common.	13.6
TM 1	SHALE: Mixed red and green; medium-bedded; small gypsum nodules locally common; green shale is present in beds, lenses, patches, and mottlings.	15.0
TM 3	SHALE: 2.8 feet of very thin-bedded green shale overlying thin-bedded red shale.	5.0

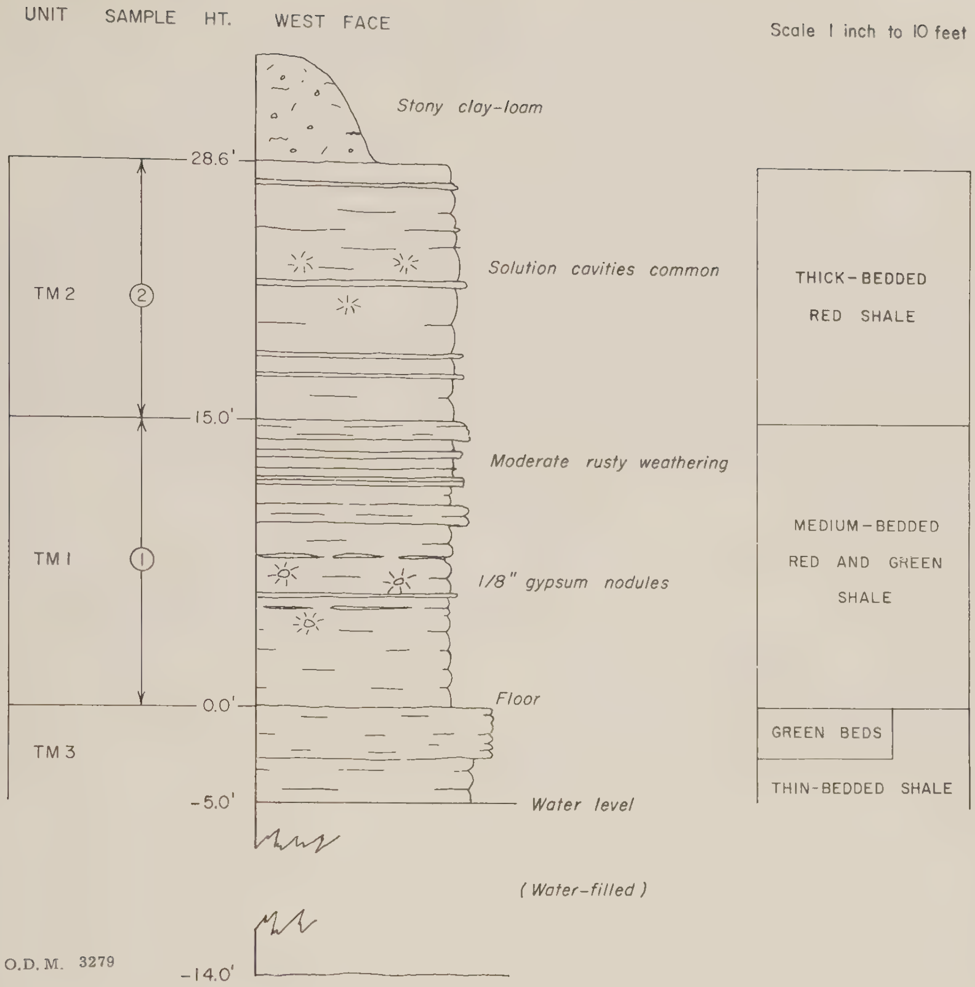

UNIT
SAMPLE
HT.
WEST FACE
Scale 1 inch to 10 feet
Stony clay-loam
28.6'
Solution cavities common
TM 2
②
THICK-BEDDED RED SHALE
15.0'
Moderate rusty weathering
MEDIUM-BEDDED RED AND GREEN SHALE
TM 1
①
1/8" gypsum nodules
0.0'
Floor
GREEN BEDS
TM 3
-5.0'
Water level
THIN-BEDDED SHALE
(Water-filled)
O.D.M. 3279
-14.0'

Figure 22—Toronto Brick Co. Ltd., Milton quarry section.

TABLE 79 Chemical Analyses:
Toronto Brick Company Limited, Milton Quarry

Sample	1	2	Composite
Height above floor (*feet*)	0.0–15.0	15.0–28.6	0.0–28.6
	(*percent*)	(*percent*)	(*percent*)
SiO_2			49.26
Al_2O_3			14.1
Fe_2O_3	5.97	6.58	5.90
CaO	9.90	7.90	9.47
MgO			3.85
Na_2O			0.42
K_2O			3.81
TiO_2			0.66
CO_2			7.88
H_2O+ (combined)			3.00
H_2O- (moisture)			0.80
SO_3			0.16
TOTAL			99.3
Loss on ignition	12.80	11.14	11.75
Soluble salts	0.70	0.50	

TABLE 80 Mineral Analyses:
Toronto Brick Company Limited, Milton Quarry
A = abundant; B = moderate; ND = not detected)

Sample	1	2	Composite
Height above floor (*feet*)	0.0–15.0	15.0–28.6	0.0–28.6
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	19	20	24
Calcite	18	10	13
Dolomite	ND	3	2
Soda-lime feldspar	ND	ND	ND
Potash feldspar	ND	ND	ND
Clay minerals			
Illite	A	A	A
Chlorite	B	B	B
Expanding minerals	ND	ND	ND

TABLE 81 Ceramic Tests: Toronto Brick Company Limited, Milton Quarry

SAMPLE 1: 0.0′–15.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.9
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	0.2
Colour	light salmon	pink-tan	buff-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	13.3	12.8	9.9
5-hour absorption (%)	15.2	15.6	13.4
Specific gravity	1.87	1.87	1.89

SAMPLE 2: 15.0′–28.6′

Water of plasticity (*percent*)	18
Lineal drying shrinkage (*percent*)	3.2
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3	0.5	0.8
Colour	dark salmon	salmon-red	brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	12.0	11.3	8.6
5-hour boil absorption (%)	19.1	13.7	11.8
Specific gravity	1.91	1.92	1.95

REMARKS: Fired briquettes are marked by a trace of white scum. Briquettes fired to cone 03 are slightly blistered and overfired.

shovel. Loads of 20–25 tons were hauled to the Don Valley plant in trailer trucks, and a stockpile of the shale was maintained in an inactive part of the Don Valley quarry.

The 30-foot shale face is illustrated in figure 22 and described in the accompanying section. The results of chemical, mineralogical, and ceramic testwork are given in tables 79, 80, and 81.

Part IV Hamilton Shale

ODM7451

Photo 27–Hamilton shale in the quarry of George Coultis and Son Limited, Thedford.

Soft grey shale of the Hamilton Formation is used by a brick plant at Parkhill and a tile plant at Thedford in southwestern Ontario. The formation forms the bedrock in a belt 5–20 miles wide, extending northwesterly from Lake Erie to Lake Huron, in the western parts of Elgin and Middlesex counties and northern Lambton county. To the southwest it is overlain by the black Kettle Point and Port Lambton shales, but it forms the bedrock again in western Kent county as well as in portions of central Lambton county. Exposures are scarce, but good sections may be seen at Stoney Point on Lake Huron, on the Ausable River near Arkona, in the Canadian National Railway cut and the tile yard northeast of Thedford, and on Sydenham River at Smiths Falls (Caley 1943, p. 51). The Hamilton Formation is the bedrock for the areas indicated in Map 2131 (see back pocket).

HAMILTON FORMATION

Hamilton shale is of middle Devonian age. The term "Hamilton" was introduced in describing similar rocks at Hamilton, in Madison county, New York. The Hamilton Formation in Ontario includes both limestone and shale, in some places with an abundance of fossils. Finely crystalline, buff-coloured limestone of the Dundee Formation underlies grey Hamilton shale, and the contact is sharp. Dark brown or black bituminous shale of the Kettle Point Formation overlies the Hamilton Formation, and the contact is sometimes marked by 10–30 feet of green shale that forms the base of the Kettle Point beds (Caley 1943, p. 58).

LITHOLOGY AND SUBDIVISION OF THE HAMILTON FORMATION

B. V. Sanford and W. B. Brady (1955, p. 7) describe the Hamilton Formation as follows:

> The Hamilton formation is divided into four members, in descending order: Ipperwash limestone, Petrolia shale, Widder beds, and Olentangy shale. Both the Olentangy and Petrolia members consist of soft, light grey, calcareous shale. The Olentangy varies in thickness from 25 to 100 feet and the Petrolia from 70 to 190 feet. Occasional limestone interbeds occur within the shales, and in many places at the base of the Olentangy there is a 5- to 10-foot bed of grey limestone. The Widder member is a fine to medium crystalline, argillaceous limestone from 5 to 20 feet thick, lying between the two shale members. The Ipperwash member, from 20 to 130 feet thick, consists of grey, fine-grained, argillaceous limestone with minor interbeds of crystalline limestone. Shale is common throughout. All members vary in thickness from one locality to another, and cannot always be recognized in well cuttings. Their combined thickness may total over 300 feet.

CERAMIC PROPERTIES

Soft shale of the Petrolia Member of the Hamilton Formation readily breaks down with weathering; when wet it is easily worked into a smooth plastic condition, and has most of the properties of a natural clay. It burns to a medium red-brown colour and has a moderate firing range. The burned colour weakens in sections containing appreciable lime. If not compensated for by a suitable additive, excessive white scum is a deleterious feature of the fired shale body.

Average ceramic properties of four samples taken from the only two active Hamilton shale quarries in Ontario are shown in Table 82.

TABLE 82 Ceramic Properties of Hamilton Shale

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	4.4
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	2.1	3.3
24-hour cold water absorption (%)	15.6	10.1	6.5
5-hour boil absorption (%)	16.0	11.3	7.2

CHEMICAL COMPOSITION

Analyses of the shale from the two active quarries show negligible variation, strengthening the view that the two sections, although 8 miles apart, occupy the same stratigraphic position. Limestone and limy shale are common at intervals throughout the formation, but samples of the typical shale of the Petrolia Member show a range in lime (CaO) content from 5 to 10 percent. Iron oxide (Fe_2O_3) ranges from 6 to 7 percent, and the content of soluble salts ranges from ½ to 1 per cent.

TABLE 83 Chemical Composition of Hamilton Shale

	Percentage
SiO_2	51.64
Al_2O_3	16.9
Fe_2O_3	6.37
CaO	6.55
MgO	2.39
Na_2O	0.22
K_2O	3.85
TiO_2	0.88
CO_2	5.63
H_2O+	3.91
H_2O-	0.60
SO_3	0.62
TOTAL	99.6

The average composition of the shale, based on composites of channel samples from the two quarries, is shown in Table 83.

MINERAL COMPOSITION

X-ray diffraction studies of four channel samples from the only two active quarries indicate that the average content of clay minerals in Hamilton shale (upper part of the Petrolia Member) is 63 percent. Illite and chlorite both occur in abundance, but expanding-type clay minerals are absent. The average composition of the non-clay fraction, as determined by the Laboratory Branch, Ontario Department of Mines, is shown in Table 84.

TABLE 84 Non-clay Minerals in Hamilton Shale

	Average of 4 samples	Range
	(*percent*)	(*percent*)
Quartz	26	24–28
Calcite	10	6–13
Dolomite	0.2 (approx.)	0–<0.5
Soda-lime feldspar	0.2 (approx.)	0–<0.5
Potash feldspar	0.2 (approx.)	0–<0.5

ODM7451

Photo 28–George Coultis and Son Limited; drying racks 1965.

Producers Using Hamilton Shale

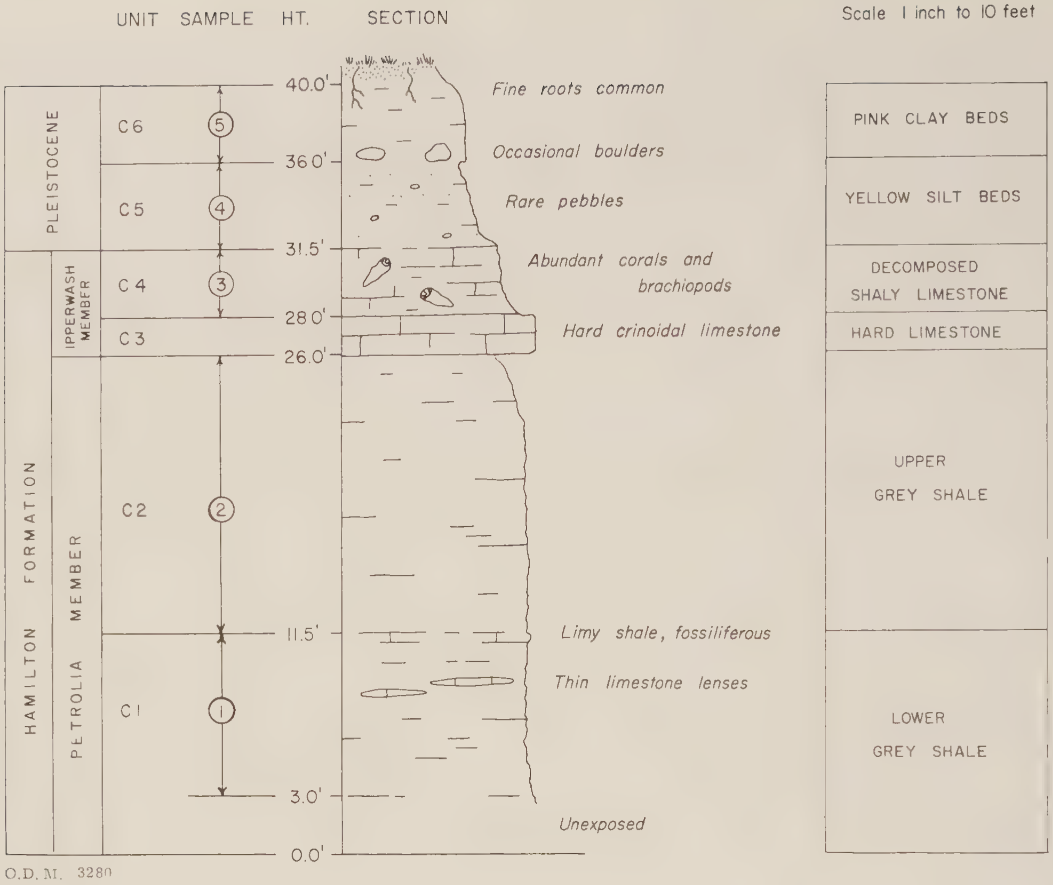
GEORGE COULTIS AND SON, LIMITED

Drain tile is manufactured from Hamilton shale at a plant one mile north of Thedford. The plant has changed hands several times and was purchased by the Coultis family in 1931. It is situated in lot 23, concession III, Bosanquet township, Lambton county. Early descriptions of the plant and shale are given by Baker (1906, p. 75), Keele (1924, pp. 26–27, 110), and Montgomery (1930, pp. 132–133).

Plant

The annual production is about 1 million drain tile, predominantly in the smaller sizes. Brick and partition tile have not been made since 1963, when the plant was partly destroyed by fire. The operation employs 10 men for a season of 8 months.

Stripping of the 10 to 15 feet of clay overburden is accomplished by a Cletrac bulldozer-loader. Only shale below the 2-foot limestone bed (see figure 23) is used in the plant. It is easily removed, without blasting, by a ½-yard Northwest gasoline shovel. The soft shale is piled on the pit floor to take advantage of natural weathering, and it is frequently worked-over and watered to improve its workability. A 1-yard Hough Payloader reclaims the shale and loads a Parkhill double-shaft pug feeder located on the pit floor. Barium carbonate is added manually at the feeder, at the rate of 2 or 3 pounds per ton of shale. The shale is conveyed to the plant on an 18-inch belt,


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 10 feet
PLEISTOCENE
HAMILTON FORMATION
IPPERWASH MEMBER
PETROLIA MEMBER
C6
C5
C4
C3
C2
C1
5
4
3
2
1
40.0'
36.0'
31.5'
28.0'
26.0'
11.5'
3.0'
0.0'
Fine roots common
Occasional boulders
Rare pebbles
Abundant corals and brachiopods
Hard crinoidal limestone
Limy shale, fossiliferous
Thin limestone lenses
Unexposed
PINK CLAY BEDS
YELLOW SILT BEDS
DECOMPOSED SHALY LIMESTONE
HARD LIMESTONE
UPPER GREY SHALE
LOWER GREY SHALE
O.D.M. 3280

Unit		Thickness (*feet*)
PLEISTOCENE		
C 6	CLAY: Brown, weathering pink-white; smooth, blocky, crumbly top; uniform 1-inch bedding; stained grey-green on fractures and joints; fine roots common; occasional rounded boulders at base of unit.	4.0
C 5	SILT: Yellow-brown, drying buff-yellow; laminated ($\frac{1}{4}$–1 inch) silty clay and silt; rare pebbles to 1-inch, average $\frac{1}{4}$-inch; rusty joints and fractures; bedding is truncated at a low angle against the upper unit.	4.5
HAMILTON FORMATION		
C 4	SHALY LIMESTONE: Grey; soft; deeply-weathered; abundant fossil corals.	3.5
C 3	LIMESTONE: Brown weathering to grey; hard; medium-grained; medium-bedded; abundant crinoid fragments; several thin shaly interbeds.	2.0
C 2	SHALE: Grey; uniform; moderately hard, upper 4 feet are soft; bedding indistinct; weathers to elongated fragments 1–2 inches thick; occasional rusty haloes around former worm-borings or root channels.	14.5
C 1	SHALE: Medium-grey to green-grey; soft to moderately hard; bedding indistinct, appears massive; weathers to smooth elongated fragments 1–2 inches thick; occasional rusty haloes; efflorescence common; several platy lenses of brown fossiliferous limestone.	11.5

Figure 23–George Coultis and Son Ltd., quarry section.

150 feet long, and is discharged directly to an 18-inch Steele model A disintegrator. The disintegrator discharge passes directly to a Parkhill double-shaft pug mill where tempering water is added as required. A set of 36-inch diameter, 12-inch, Steele smooth-faced double rolls set at an opening of 1/16-inch precedes extrusion by an F-R-H Hummer pug and auger machine. Tile are extruded in a single stream without de-airing, and are cut by a Fate cutter. They are hacked in 3 tiers, 96 tile to a car.

Natural drying is accomplished on 58 shed-covered tracks, each track holding 24 cars. There are 4 beehive kilns with inside diameters of 22 to 25 feet and capacities of 16,000 to 20,000 tile each. They are wood-fired to about 1800°F and turned over on 14-day cycles.

TABLE 85 Chemical Analyses: George Coultis and Son, Limited

Sample	1	2	Composite	3	4	5
Height above floor (*feet*)	3.0–11.5	11.5–26.0	3.0–26.0	28.0–31.5	31.5–36.0	36.0–40.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	*percent*()	(*percent*)
SiO_2			51.32			
Al_2O_3			15.7			
Fe_2O_3	6.03	7.05	6.35	3.05	3.33	4.22
CaO	10.2	5.32	6.63	30.9	19.1	14.1
MgO			2.34			
Na_2O			0.23			
K_2O			3.88			
TiO_2			0.87			
CO_2			5.90			
H_2O+			3.88			
H_2O-			0.51			
SO_3			0.74			
TOTAL			98.4			
Loss on ignition	12.60	8.82	9.66	25.01	19.60	18.32
Soluble salts	0.90	0.73		0.72	0.42	0.56

TABLE 86 Mineral Analyses: George Coultis and Son, Limited
(A = abundant; B = moderate; C = minor; D = trace; ND = not detected)

Sample	1	2	Composite	3	4	5
Height above floor (*feet*)	3.0–11.5	11.5–26.0	3.0–26.0	28.0–31.5	31.5–36.0	36.0–40.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals						
Quartz	24	28	29	16	27	21
Calcite	13	6	8	52	21	16
Dolomite	<0.5	<0.5	<0.5	6	16	16
Soda-lime feldspar	ND	ND	<0.5	ND	4	2
Potash feldspar	ND	ND	<0.5	ND	2	ND
Amphibole						<1
Clay minerals						
Illite	A	A	A	B	B	B
Chlorite	A	A	B	C	C	B
Expanding minerals	ND	ND	ND	ND	D	C

GEOLOGY

The east wall of the quarry is illustrated in figure 23. The lower 26 feet consist of soft shale belonging to the Petrolia Member of the Hamilton Formation; the overlying limestone may belong to the Ipperwash Member (Caley, 1943, p. 55–56). The soft, decomposed, shaly limestone at the top of the Hamilton section is noted for its abundance of fossil corals. Stauffer (1915, pp. 173–176) describes the section and gives a detailed list of the fossils.

The quarry is developed in the valley of Decker Creek to take advantage of a minimum thickness of overburden. Only the shale is used for making tile; the limestone layers, and the stratified Pleistocene silts and clays, are stripped as waste.

The quarry section is described in the following notes. In addition to the shale units, some of the upper units in the section were also sampled. The results of chemical, mineralogical, and ceramic testing of the vertical channel samples are given in tables 85, 86, 87.

TABLE 87 Ceramic Tests: George Coultis and Son, Limited

SAMPLE 1: Hamilton shale 3.0′–11.5′

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	4.4
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2 expansion	0.3	0.2
Colour	light brown	medium brown	grey brown
Hardness	hard	almost hard	hard
24-hour absorption (%)	15.6	13.4	11.3
5-hour boil absorption (%)	15.6	15.7	13.2
Specific gravity	1.76	1.78	1.79

REMARKS: Fired briquettes are marked with an abundance of white scum.

SAMPLE 2: Hamilton shale 11.5′–26.0′

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	4.7
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2 expansion	2.8	5.1
Colour	light brown	medium brown	dark brown
Hardness	almost hard	almost hard	hard
24-hour absorption (%)	16.4	9.2	4.7
5-hour boil absorption (%)	17.0	10.1	4.9
Specific gravity	1.77	1.97	2.12

REMARKS: Fired briquettes are attractive except for the abundance of white scum.

SAMPLE 3: Hamilton shaly limestone 28.0′–31.5′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	2.3
Pyrometric cone equivalent	8

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.3	1.4	2.2
Colour	tan-grey	cream-grey	grey-buff
Hardness	soft	soft	soft

REMARKS: Fired briquettes had an unattractive dark speckled appearance. All crumbled before or during the absorption tests.

SAMPLE 4: stratified silt and clay 31.5′–36.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.0
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.7	1.7	1.4
Colour	light salmon	tan	buff
Hardness	almost hard	soft	soft
24-hour absorption (%)		21.9	19.8
5-hour boil absorption (%)		26.1	26.2
Specific gravity		1.58	1.57

REMARKS: Briquettes fired at cone 010 crumbled after brief exposure to the air. Other briquettes are marked by some dark specking.

SAMPLE 5: clay 36.0′–40.0′

Water of plasticity (*percent*)	22
Lineal drying shrinkage (*percent*)	5.3
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4	0.4	1.4
Colour	light salmon	tan	buff
Hardness	almost hard	hard	very hard
24-hour absorption (%)	18.6	17.4	13.1
5-hour boil absorption (%)	19.7	18.6	15.6
Specific gravity	1.71	1.72	1.76

REMARKS: Fired briquettes are marked by a slight specking.

PARKHILL BRICK COMPANY LIMITED

J. W. Wright is the manager of a brick plant on the northern limits of Parkhill in lot 5, concession XX, West Williams township, Middlesex county. This was one of the plants owned by the H. C. Baird Company, which was established in 1869 and became a leading manufacturer of clay-working machinery from 1885 to 1932. Brick production was renewed by Mr. Wright in 1956. Early descriptions of the plant and clay are given by Baker (1906, p. 80), Keele (1924, p. 27), and Montgomery (1930, p. 137).

Plant

The average annual production is 1 million stiff-mud brick. These are largely Ontario size but some Norman and Roman sizes are also made. The plant is operated the year round and employs 7 men.

Hamilton shale is received at the plant by truck and surface clay is obtained from a pit behind the plant. Colour is largely determined by proportioning the buff-burning clay and red-burning shale. Batching is accomplished by a Trojan front-end loader which reclaims clay, shale, and waste-brick grog from a small covered storage area. A 5-foot diameter American drypan is loaded manually. It is in closed circuit with a 10-mesh Tyler 4-foot by 8-foot heated vibrating screen. Ground shale is stored in a bin of 8000-brick capacity, and is fed as required into a Plymouth Special combined pug, de-airing, auger machine. Brick are extruded in a single stream at the rate of 2,200 per hour under a vacuum of 23 inches. Cutting is by a Frey Universal machine.

Drying is accomplished in a 6-track waste heat tunnel dryer, 70 feet long, with a capacity of 30,000 brick. The drying time is 14 hours. Two beehive kilns of 26-foot inside diameters hold 40,000 brick each. They are fired with a mixture of bunker and fuel oil, and the production averages 2½ kilns per month.

The brick are dipped in a Dow Corning silicone as removed from the kiln. Mr. Wright claims that absorption and efflorescence are greatly reduced by this treatment. When dry, the brick are stacked on wooden pallets in the yard. Shipments are made by truck.

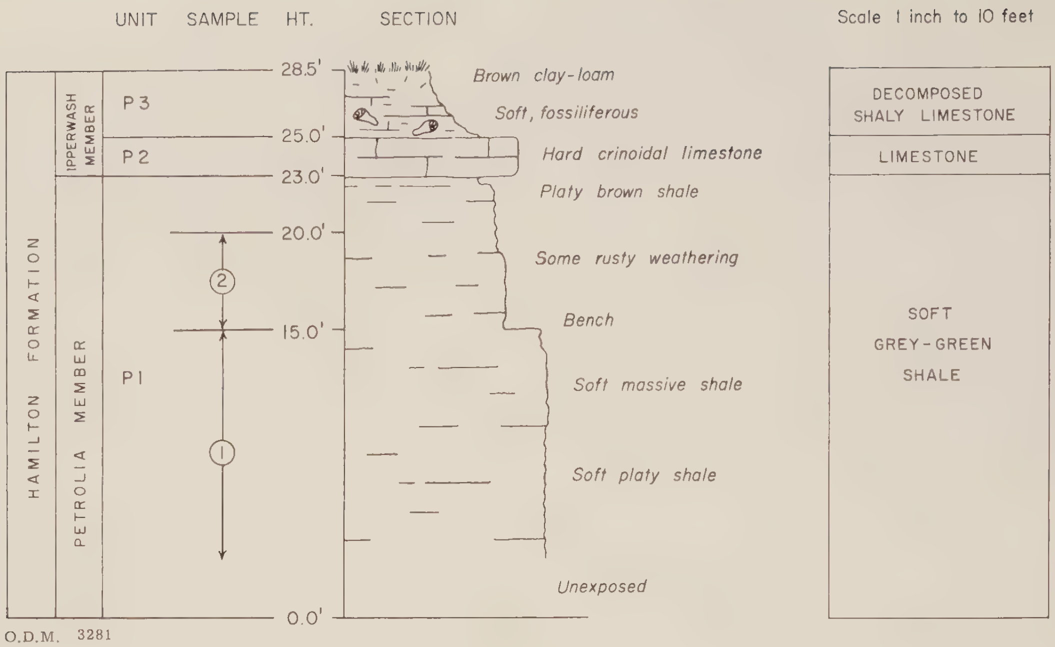
GEOLOGY

Buff-coloured brick are the main products of the Parkhill plant. Hamilton shale from an exposure on the Ausable River, 11 miles southwest of Parkhill, normally comprises one-third of the batch; the rest is surface clay from a pit adjoining the plant.

The clay pit is circular in plan, about 75 feet in diameter, with an 8-foot face. Platy-bedded yellow-brown silt and dark brown clay comprise most of the 8-foot section. Small whorls, pockets, and stubby lenses of fine yellow sand are locally common, deflecting the bedding both above and below. Dense, blue-grey, silty clay is exposed in the floor of the pit, but silt predominates in the upper part of the section. The top 1–2 feet are loamy and contain a moderate number of fine roots. Sod and topsoil, containing a few white shells and angular limestone fragments, are stripped to a depth of 1–1½ feet.

The shale quarry is located at Marsh's Mills, 2 miles east of Arkona, on the north bank of the Ausable River in West Williams township, Middlesex county. An earlier course of the river has resulted in the removal of overburden at this point. On the south bank, 50 feet of overburden cover several 3-foot layers of medium-bedded limestone that form a capping for the soft shales below. The limestone zone may belong to the Ipperwash Member of the Hamilton Formation, or it may be included with the shales in the upper part of the Petrolia Member (Caley 1943, p. 55–56). The section is also described by Stauffer (1915, pp. 156–162). The quarry occupies an area of 200 feet square, and is worked in two benches. The soft shale is easily excavated by scraper. Shale is stockpiled at the plant, and the quarry is only worked for a few weeks each year.

The shale section is illustrated in figure 24 and described on an accompanying page. The results of chemical, mineralogical, and ceramic testing of channel samples of both the shale and clay (sample 3) are given in tables 88, 89, 90.


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 10 feet
HAMILTON FORMATION
PETROLIA MEMBER
IPPERWASH MEMBER
P 3
P 2
P 1
28.5'
25.0'
23.0'
20.0'
15.0'
0.0'
②
①
Brown clay-loam
Soft, fossiliferous
Hard crinoidal limestone
Platy brown shale
Some rusty weathering
Bench
Soft massive shale
Soft platy shale
Unexposed
DECOMPOSED SHALY LIMESTONE
LIMESTONE
SOFT GREY-GREEN SHALE
O.D.M. 3281

Unit		Thickness (*feet*)
P 3	SHALY LIMESTONE: Grey to orange-brown; deeply weathered, soft and loamy; abundant corals and brachiopods.	3.5
P 2	LIMESTONE: Brown, weathering to grey; hard; medium-grained; medium-bedded; abundant crinoid fragments; several thin interbeds of soft platy brown shale.	2.0
P 1	SHALE: Green-grey, weathering to very light grey; soft; bedding indistinct; platy parting produces smooth elongated fragments 1–2 inches thick, caused by weathering; some rusty-brown colouration at top; occasional fossils.	23.0

Figure 24—Parkhill Brick Co. Ltd., quarry section.

TABLE 88 Chemical Analyses: Parkhill Brick Company Limited

Sample	1	2	Composite	3
Height above floor (*feet*)	3.0–15.0	15.1–20.0	3.0–20.0	0.0–8.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2			51.96	
Al_2O_3			18.1	
Fe_2O_3	6.30	6.35	6.40	2.05
CaO	6.87	5.27	6.48	21.1
MgO			2.45	
Na_2O			0.21	
K_2O			3.82	
TiO_2			0.89	
CO_2			5.36	
H_2O+			3.95	
H_2O-			0.70	
SO_3			0.50	
TOTAL			100.8	
Loss on ignition	10.54	9.10	9.74	23.15
Soluble salts	0.51	1.01		0.30

TABLE 89 Mineral Analyses: Parkhill Brick Company Limited

(A = abundant; B = moderate; C = minor; D = trace; ND = not detected)

Sample	1	2	Composite	3
Height above floor (*feet*)	3.0–15.0	15.0–20.0	3.0–20.0	0.0–8.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	24	27	27	16
Calcite	10	6	9	11
Dolomite	ND	ND	<0.5	25
Soda-lime feldspar	<0.5	<0.5	<0.5	4
Potash feldspar	<0.5	<0.5	<0.5	<0.5
Clay minerals				
Illite	A	A	A	B
Chlorite	A	A	B	C
Expanding minerals	ND	ND	D	D

TABLE 90 Ceramic Tests: Parkhill Brick Company Limited

SAMPLE 1: Hamilton shale 3.0′–15.0′

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	4.3
Pyrometric cone equivalent	6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Linea firing shrinkage (%)	0	1.7	2.6
Colour	light brown	red-brown	rust-brown
Hardness	almost hard	very hard	very hard
24-hour absorption (%)	15.4	10.1	6.3
5-hour boil absorption (%)	16.1	11.1	6.7
Specific gravity	1.77	1.87	1.94

REMARKS: White scum is abundant on fired briquettes. Briquettes are slightly overfired at cone 03.

SAMPLE 2: Hamilton shale 15.0′–20.0′

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	4.3
Pyrometric cone equivalent	6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	3.5	5.2
Colour	light brown	red-brown	dark brown
Hardness	almost hard	very hard	very hard
24-hour absorption (%)	15.0	7.9	3.6
5-hour boil absorption (%)	15.5	8.3	3.9
Specific gravity	1.78	1.99	2.11

REMARKS: Fired briquettes are moderately coated with white scum. Briquettes are overfired at cone 03.

SAMPLE 3: Clay 0.0′–8.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.1
Pyrometric cone equivalent	8

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.7	2.1	2.8
Colour	tan	tan-buff	tan-buff
Hardness	moderately soft	soft	soft
24-hour absorption (%)	29.1	27.9	27.4
5-hour boil absorption (%)	32.4	34.0	35.1
Specific gravity	1.48	1.44	1.40

Part V Clay Deposits

Clay was the principal raw material for 33 brick and tile plants in Ontario in 1964. Drain tile was the major product in 27 of these plants; 4 were principally brick producers, and 2 sewer pipe. Local clays were also an important constituent of shale brick in 6 plants. Clay has not been used for light-weight aggregate in Ontario.

Clay is widespread in Ontario, but except for a kaolinite occurrence in the lowland south of James Bay, it is all of the low-grade illite type. Compositions of these illite clays are related to the bedrocks from which they were derived during glacial stages of the Pleistocene epoch. The close relationship that exists between unconsolidated surface deposits and the immediately underlying bedrocks has been mentioned by Hewitt and Karrow (1963, p. 34) with respect to sand and gravel, and by Guillet (1964, p. 9–10) with respect to clay. Because of the prevalence of limestones in the Paleozoic rocks of southern Ontario most of the clays in the populated areas are limy; they have short firing ranges and tend to produce soft, porous, buff-coloured bodies. Leaching and weathering have reduced the content of lime in the upper few feet of most clay deposits, contributing to a denser, harder body and a red fired colour. Red-burning clays are also derived from non-calcareous rocks, such as shale and granite.

A knowledge of the glacial events during the Pleistocene epoch is important for an understanding of the distribution and composition of Ontario clays. The glaciers deposited till—unstratified mixtures of clay, sand, and stones of all sizes—composed of soil and rock fragments gouged from the bedrock. Varved clays were deposited in glacial lakes and ponds that formed along the melting edges of the ice sheets. In warm climates stratified clay, silt, and sand, largely re-sorted from till on adjacent land surfaces, were deposited in lakes and ponds, and on the flood plains of rivers. The following section on the glacial history of southern Ontario is taken from Hewitt and Karrow (1963, pp. 17–23).

GLACIAL HISTORY OF SOUTHERN ONTARIO

Field work in United States and Canada has revealed evidence of four major cold intervals (glacial stages) during which great ice-sheets spread over the region of the Great Lakes from the north and northeast. Following each cold interval there has been a warm interval (interglacial stage) as warm as or warmer than our present climate. Most authorities believe we are now in an interglacial stage and that, thousands of years from now, ice-sheets will once again cover southern Ontario. During the interglacial stages, the ice-sheets were very much diminished in area, although it has not been established whether or not they completely disappeared.

In Canada, where field studies are, generally, less advanced than in United States, only some of the glacial and interglacial stages have been recognized. The subdivisions of the Pleistocene Epoch or "ice age" are shown in [the table below].

Subdivisions of the Pleistocene epoch

Interglacial Stages	Glacial Stages
Recent*	
	Wisconsinan*
Sangamonian*	
	Illinoian*
Yarmouthian	
	Kansan
Aftonian	
	Nebraskan

*Deposits present in southern Ontario.

Only the deposits of the last ice-sheet are known in any detail, because older deposits have been largely removed by later erosion; the remaining portions of the older deposits are buried under, and concealed by, later deposits. Study of deep exposures along rivers and lake bluffs has revealed the presence of these older deposits, and it is assumed that each glaciation laid down a variety of materials similar to those of the last glaciation.

Presented here is a summary of the events that took place when the various deposits were laid down. Most of the discussion deals with the retreat of the last ice-sheet because more information is available and because most of the known gravel [and clay] deposits were formed at that time.

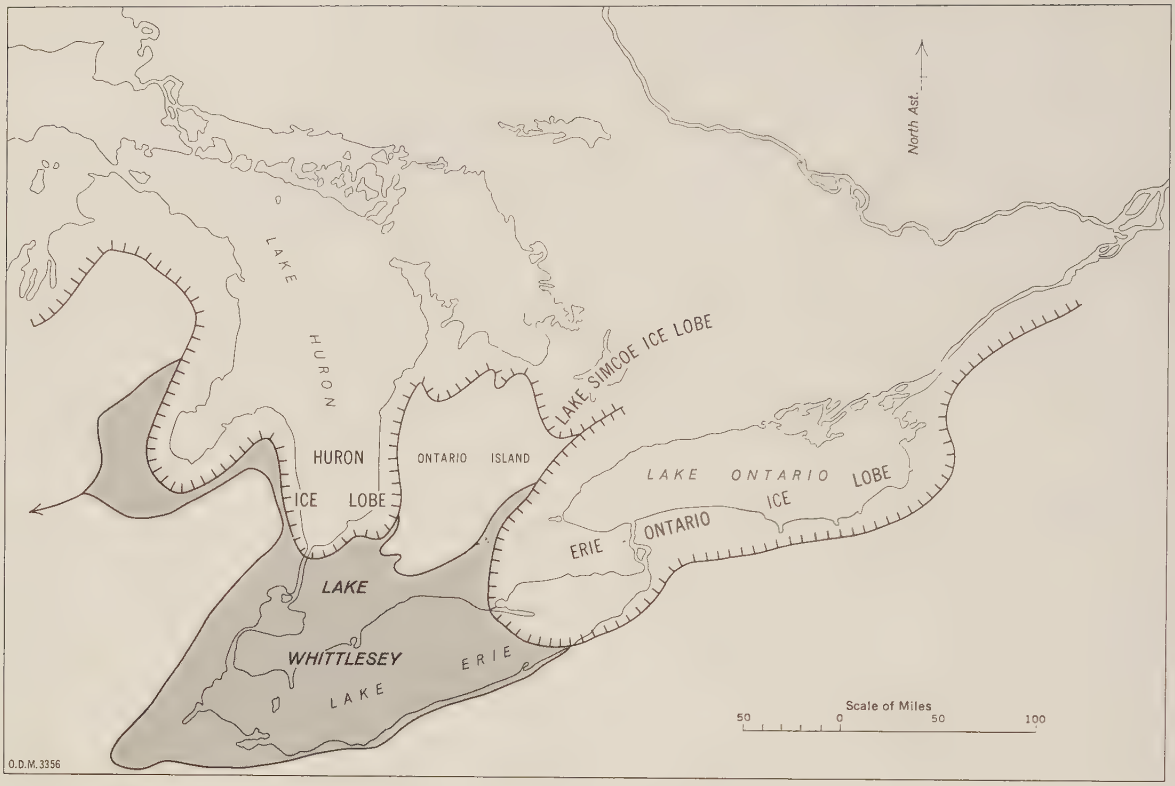
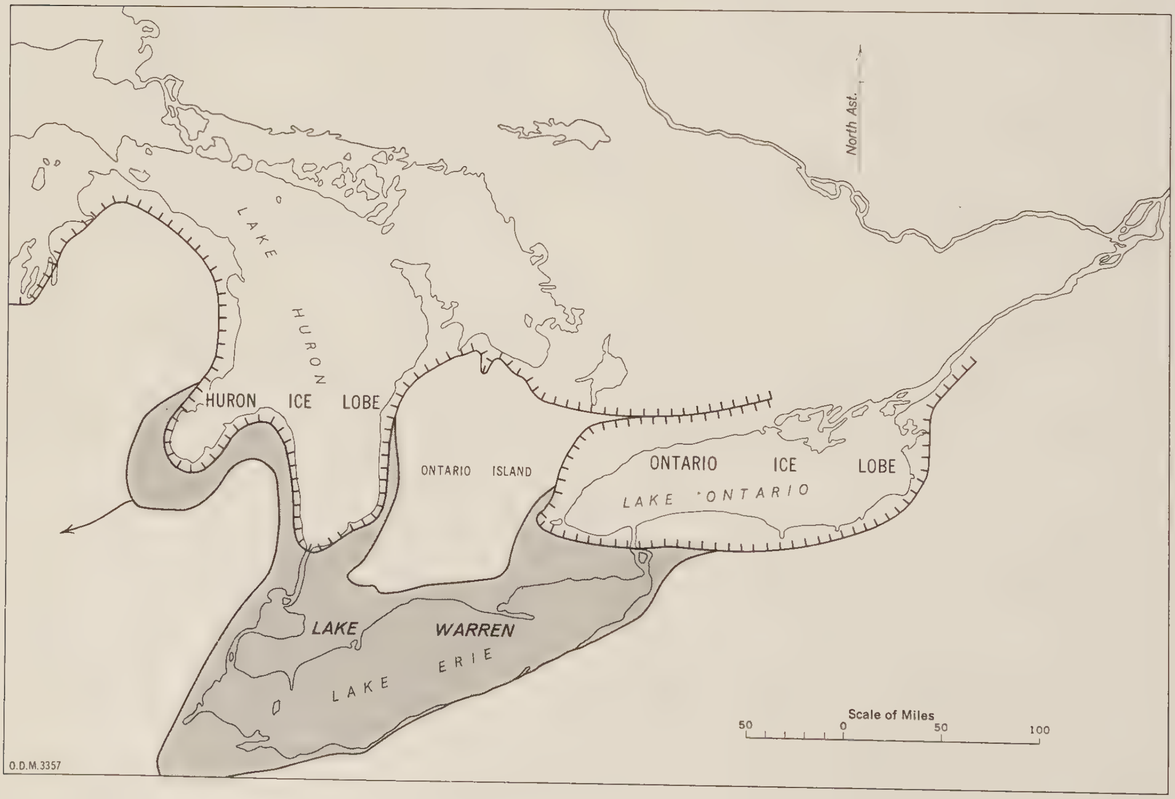

North Ast.
LAKE HURON
LAKE SIMCOE ICE LOBE
HURON ICE LOBE
ONTARIO ISLAND
LAKE ONTARIO
ONTARIO ICE LOBE
ERIE
ONTARIO
LAKE WHITTLESEY
LAKE ERIE
Scale of Miles
50
0
50
100
O.D.M.3356

Figure 25–Ice-front position at the time of Lake Whittlesey.

Figure 26–Ice-front position at the time of Lake Warren.


North Ast.
LAKE HURON
HURON ICE LOBE
ONTARIO ISLAND
ONTARIO ICE LOBE
LAKE ONTARIO
LAKE WARREN
LAKE ERIE
Scale of Miles
50
0
50
100
O.D.M.3357

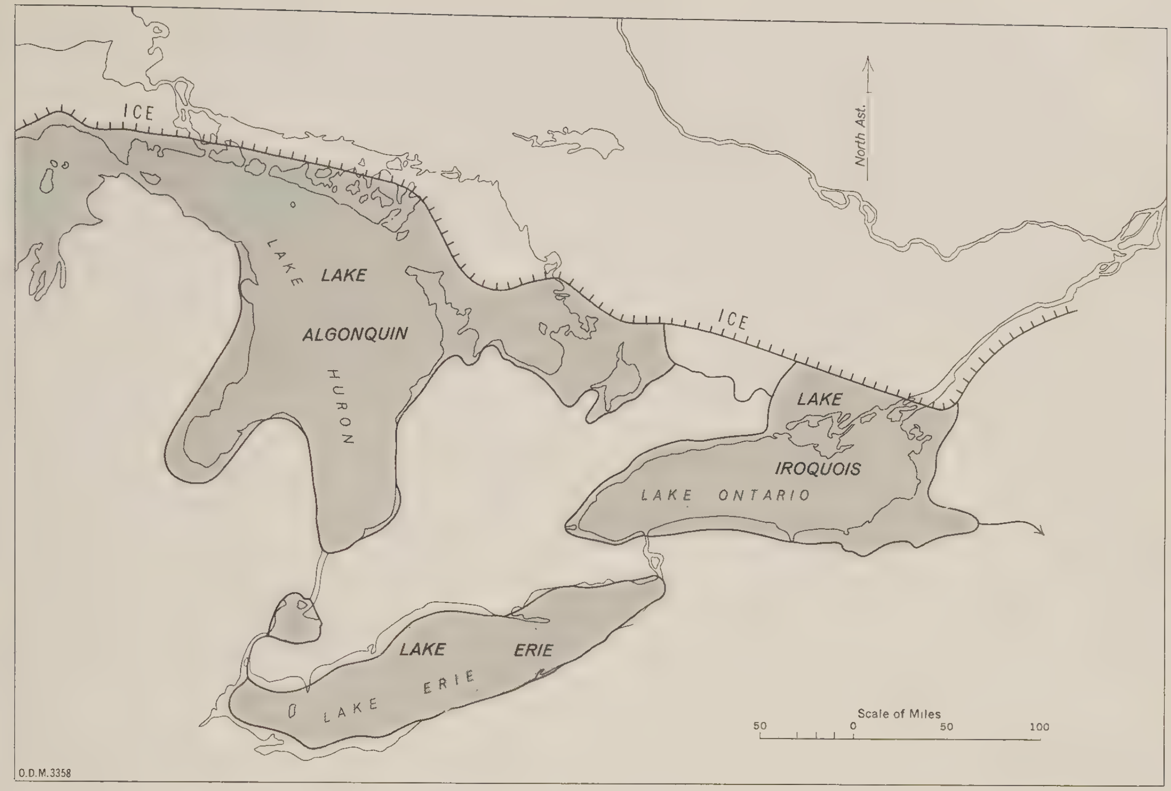
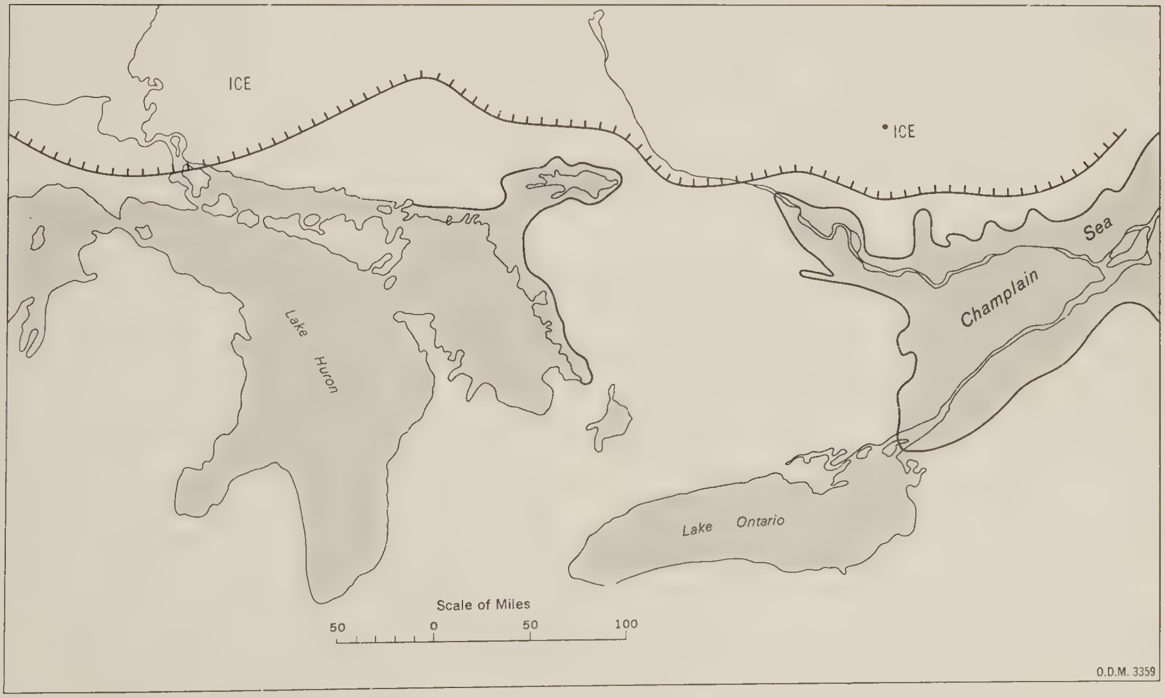

ICE
ICE
North Ast.
LAKE ALGONQUIN
LAKE HURON
LAKE IROQUOIS
LAKE ONTARIO
LAKE ERIE
LAKE ERIE
Scale of Miles
50
0
50
100
O.D.M.3358

Figure 27—Ice-front position in eastern Ontario, with Lake Algonquin and Lake Iroquois.

Figure 28—Ice-front position at the time of the Champlain Sea.


ICE
ICE
Lake Huron
Champlain Sea
Lake Ontario
Scale of Miles
50
0
50
100
O.D.M. 3359

Illinoian Stage

The only deposits in Ontario believed to be of Illinoian age are to be found in Toronto. Glacial till, heavily-charged with shale from the underlying bedrock, has been found under warm-climate interglacial beds in the Don Valley brickyard (Coleman 1933) and in excavations for subways in downtown Toronto (Watt 1954). In the latter exposures, the till is associated with glaciolacustrine varved clays. An exposure of similar till has been found recently along the Rouge River in Scarborough township (Karrow 1962). The till is usually rather thin (2–6 feet thick). The ice that deposited the till apparently moved westward out of the Lake Ontario Basin (Terasmae 1960).

Sangamonian Stage

Stratified clay, sand, and gravel (named the Don Beds) containing fossil plants and animals associated with a climate warmer than the present have been encountered at the Don Valley brickyard (Coleman 1933), in subway excavations (Watt 1954) and deep foundation excavations in downtown Toronto. They are not known to occur anywhere else in Ontario. They have a maximum thickness of about 30 feet. The sediments are considered to be stream or delta deposits formed when lake-level was about 60 feet higher than now.

Following the deposition of the Don Beds, the climate became cooler, and the lake-level rose considerably. About 150 feet of fossiliferous clay and sand (named the Scarborough Beds) were deposited at this time. Some controversy exists about the age of these beds. A radiocarbon date on the upper part of the beds gave an age greater than 52,000 years (H. de Vries, personal communication); they may be late Sangamonian or early Wisconsinan in age. Terasmae (1960) has discussed this problem. Deposits that are, perhaps, comparable in age have also been found in northern Ontario (Terasmae 1958; Terasmae and Hughes 1960b).

Wisconsinan Stage

Recent work has indicated that the Wisconsinan glaciation consists of two major ice-advances separated by a cool (but not cold) interval (Dreimanis 1958). Glacial deposits, including till, clay, and sand, assigned to the early Wisconsinan have been found in the Toronto area and along the north shore of Lake Erie (Dreimanis 1960). Ice-movement was from east to west along the Lake Ontario and Lake Erie basins.

During the cool interval that followed the retreat of the early Wisconsinan glacier, fossiliferous sands were deposited. Radiocarbon dating on plant-remains indicates an age for these deposits of 27,000 to 47,000 years before the present; during that time, the ice-front fluctuated, although it had withdrawn an unknown but considerable distance from its earlier maximum extent.

By 27,000 years ago, a major ice-advance was underway and by 20,000 years ago the ice had spread to its maximum extent, reaching as far south as southern Ohio (Goldthwait 1959). Pulsating retreat of the ice is recorded in the complex succession of end moraines and glacial lakes in the various basins of the Great Lakes.

The history of the retreat of the last ice-sheet has been covered in varying degrees of detail by several writers (Leverett and Taylor 1915; Chapman and Putnam 1951; Prest 1957; Flint 1957; Hough 1958). This history is intimately related to the complex succession of glacial lakes that were dammed up, then drained, by the fluctuating ice-front. . . .

As far as is known, all of southern Ontario was covered by glacial ice until about 14,000 years ago. The first land to appear through the retreating ice was the highland ["Ontario Island"] northwest of Orangeville, that now stands higher than 1,700 feet above sea-level. We know, however, that it was not as high then, because the great weight of the ice-sheet depressed the earth's surface, the amount of depression varying with the thickness of the ice. During and following the melting of the ice, the land gradually rose again and is still rising in some areas. Because the ice was thicker to the north, the land surface is being gradually tilted southward. The shorelines of glacial lakes are now tilted as well.

Around the first land to appear through the ice, large meltwater streams deposited their heavy load of sand and gravel to form kame-like accumulations such as are to be found in the Orangeville and Waterloo moraines. The area of exposed land increased as the ice melted back, and meltwater, dammed up by the ice, formed lakes to the southwest. Eventually the ice had melted back to the position shown in [Figure 25] along the Paris and Wyoming moraines. This is correlated with the Port Huron position in Michigan having an age of 12,800 years and the large lake that existed at that time (Lake Whittlesey) drained southwest to the Mississippi River. Lake Whittlesey left a prominent shoreline in southwestern Ontario and some of the old beach deposits have been sources of gravel. . . .

The next prominent lake was Lake Warren, which also drained to the southwest. . . . As it did in Lake Whittlesey, post-glacial uplift of the land has tilted the old shoreline to elevations that are near 875 feet north of Dundas and near 700 feet around Blenheim. The ice-front had retreated farther to stand along the Niagara Escarpment in the east and farther north in the Huron basin. This phase is shown in [Figure 26]. . . .

A major ice-retreat associated with a temporary warming of the climate caused the ice to clear part of the Ontario Basin, allowing the formation of Lake Iroquois about 12,000 years ago (Karrow, Clark, and Terasmae 1961) and its outlet down the Hudson valley. In the Huron Basin, another major glacial lake (Lake Algonquin) formed and drained into Lake Iroquois along the Trent Valley. The position of the ice-front is unknown, but it probably lay in the rough country east of Georgian Bay. . . . This phase is shown in [Figure 27].

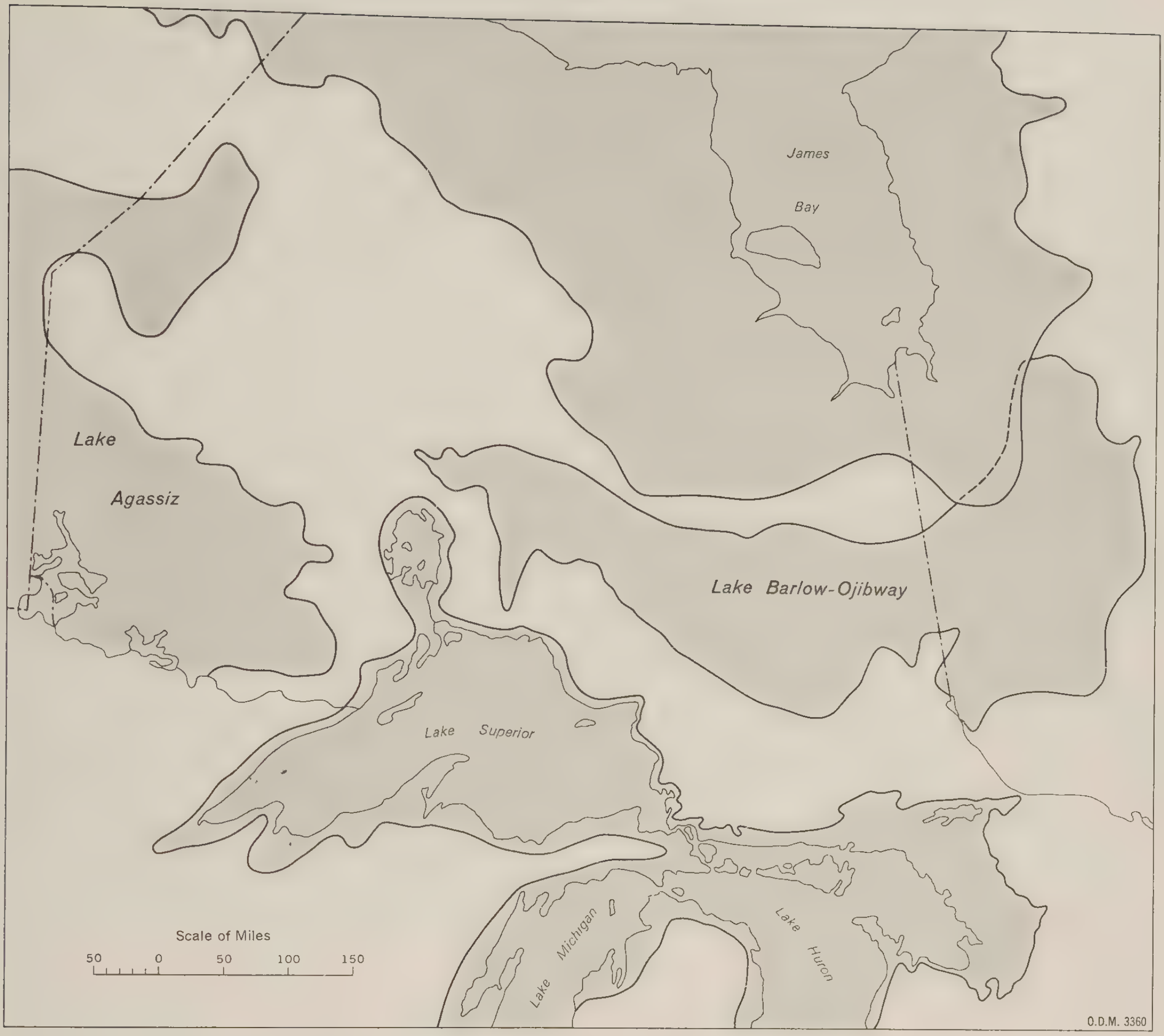


Figure 29—Maximum extent of the glacial lakes and marine submergence in northern Ontario.

As the ice retreated northward, it uncovered the St. Lawrence Valley. Having been depressed below sea-level by the weight of ice, the land east of Pembroke and Brockville was flooded by marine water to form the Champlain Sea [Figure 28]. Marine shells and whale bones have been found in the clays and beach deposits at many places covered by the sea.

Eventually, the ice melted back to free the Nipissing-Ottawa Valley, and Lake Algonquin ceased to exist because of free drainage to the east. The drainage of Lake Algonquin and the earlier part of the Champlain Sea have been dated at about 10,000 or 11,000 years ago (Terasmae and Hughes 1960a).

Gradual uplift of the land and disappearance of the ice-sheet have brought conditions to those we know today.

GLACIAL HISTORY OF NORTHERN ONTARIO

A succession of lake stages has been traced by Zoltai (1931) in the Lakehead area, while ice occupied the eastern part of the Lake Superior basin. As the ice retreated from this basin from west to east, the waters that at first drained westward to the Mississippi River found a lower outlet through the Lake Michigan basin, so forming part of a late stage of Lake Algonquin (Prest 1957, p. 479).

Some time prior to this event, and perhaps about the time of glacial Lake Whittlesey in the Lake Erie basin of southern Ontario, a large lake was forming along the ice-front west of the Lake Superior basin. This lake, known as Lake Agassiz, followed the retreating ice into northwestern Ontario, and at its maximum reached a point almost due north of the Lakehead (figure 29). Features of Lake Agassiz are described by Elson (1957), Johnston (1915, 1946), and Zoltai (1961). Prest (1957, pp. 485–487) outlines the history of Lake Agassiz as follows:

> Glacial Lake Agassiz . . . occupied, over a period of thousands of years, much of central and southern Manitoba and overlapped into Ontario and the United States. This gigantic lake may have been, at its maximum, the biggest of all our glacial lakes. It began to form in the upper part of the Red River Valley, far south of the International Boundary, and followed the retreating ice-front northward into Manitoba, and northeastward into Ontario. It discharged southward into the Mississippi River.
>
> While Lake Agassiz was expanding northward, following the retreating ice-margin, it was also expanding eastward into Ontario. An eastern outlet or outlets lower than the southern, Lake Traverse, spillway was exposed leading into the Lake Superior basin, and Lake Agassiz was largely drained.
>
> The advance of Valders ice [a temporary re-advance of the Wisconsinan glacier] west of Lake Nipigon and Lake Superior 11,000 years ago . . . closed the eastern outlet and brought about a reflooding of the Agassiz basin. The lake deepened . . . and once again discharged through the southern outlet to the Mississippi River. . . . Later retreat of the glacier from the Lake Nipigon area reopened low outlets so that the level of Lake Agassiz fell leaving a record of strand lines. Finally a northern outlet to Hudson Bay was opened and new low levels were no doubt established prior to the draining of the lake. This event is believed to have occurred about 5,000 years ago.

Concerning northeastern Ontario, Prest (1957, pp. 480–481) traces the last stages of the Wisconsinan glacier as follows:

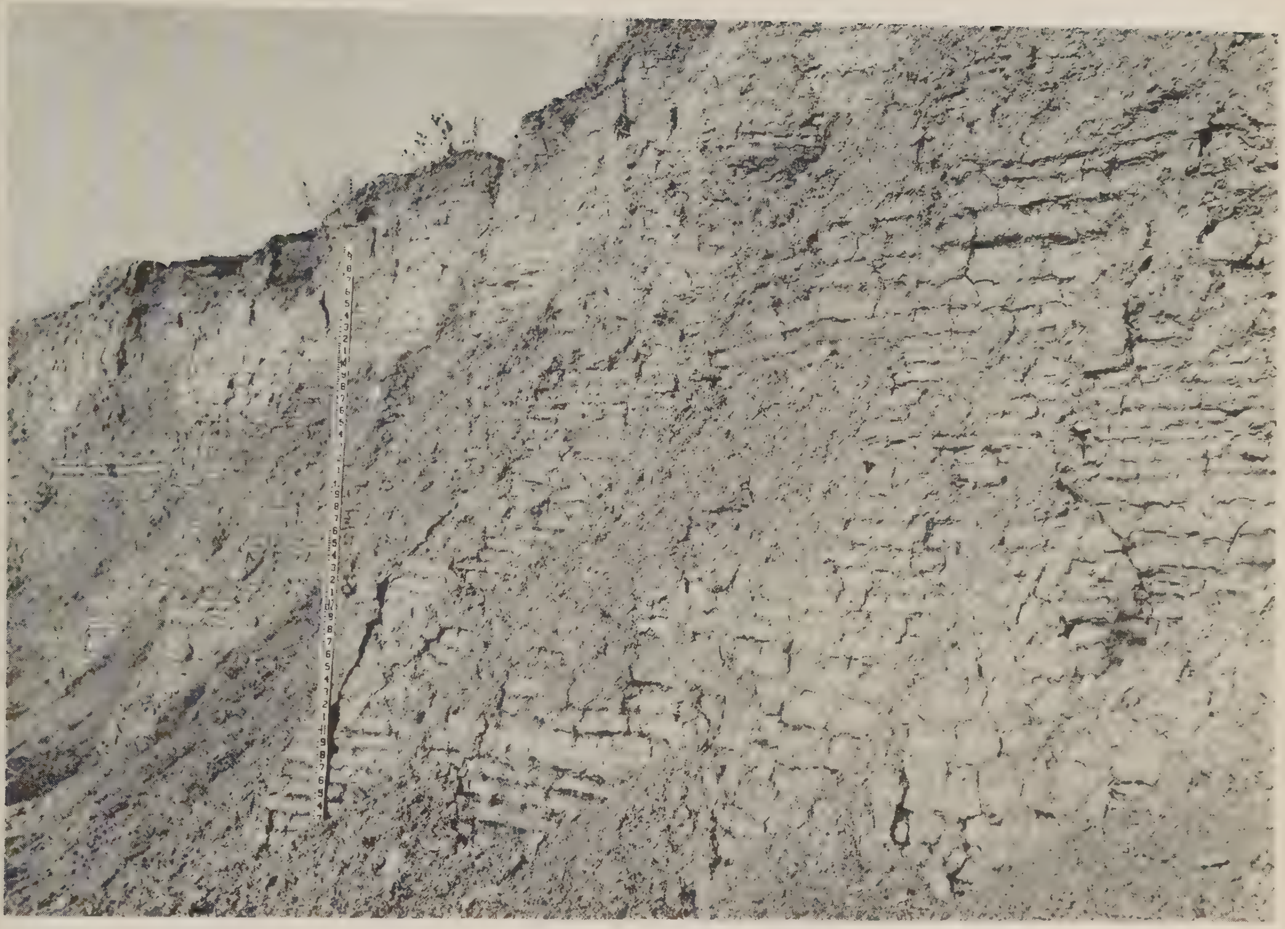
> As the Valders glaciers waned and the ice-margin reached a point beyond the height of land, north of the upper Great Lakes, the meltwater was ponded between the high ground and the ice-front. This gave rise to glacial Lake Ojibway, with its western end at a point just north of Lake Nipigon. Meltwater was also ponded in the Lake Timiskaming basin, presumably as a result of blockage of the outlet to the Ottawa River by glacial ice and debris, and gave rise to glacial Lake Barlow. With continued retreat of the glaciers to the north and northeast the waters of the two lakes merged to form glacial Lake Barlow-Ojibway [Figure 29]. This lake attained a maximum width of 150 miles and a length of about 600 miles. Many excellent raised beaches mark its former positions. It had at least two outlets into Lake Superior but its main escape route appears to have been via the Ottawa River. Later, the lake appears to have had lower, ice-confined channels northward into James Bay.
>
> Glacial Lake Barlow-Ojibway probably did not drain completely prior to a readvance of the ice-margin from a point at least 35 miles north of Cochrane to a point 35 miles south of that town. This is known as the Cochrane advance and is considered to have substage rank. This advance left a mantle of till on the varved clays of the northern part of Lake Barlow-Ojibway. The till is commonly about 15 feet thick and is locally more than 30 feet thick. A lake was no doubt ponded south of the ice-margin and hence varved sediments would be deposited in some parts of the lake basin during the Cochrane glacial stage and in the following post-Cochrane lakes stage, but differentiation of the varves of these lakes has not yet been possible. Varved sediments that occur in many places on top of the Cochrane till were apparently deposited in several small lakes. These varved deposits are usually only 3 to 5 feet thick but some are up to 15 feet.
>
> A short distance west of Cochrane a sample of wood from near the base of a 4-foot section of peat was radiocarbon dated at 6,380 ± 350 years. This peat rests on varved silts of a post-Cochrane lake stage. The Cochrane ice-advance into the Barlow-Ojibway lake basin must, therefore, have occurred some 7,000 years ago, at about the time of the "Lake Algonquin" stages in the Great Lakes basin. . . .
>
> The post-Cochrane lakes were all drained to the north when the glacier receded into James Bay. The area surrounding James Bay and Hudson Bay, being greatly depressed by the former weight of the ice, was inundated by the sea. A broad area in northern Ontario varying from 50 to 175 miles in width was flooded to an elevation of almost 500 feet.

Features of glacial Lake Ojibway are described in detail by Coleman (1909) and Antevs (1925, pp. 74–77 and 110–119).

STONY GLACIAL DEPOSITS

Most of the land surface of Ontario is mantled with rock debris left by the melting Wisconsinan glacier. Where bedrock is exposed, the smooth scoured surfaces are often marked by striations that indicate the direction of ice movement.

Much of the glacial debris is present as till. Till is an unsorted mixture of fine and coarse rock fragments deposited directly by ice. Till moraines have a smooth or gently undulating topography sometimes broken by large whale-back hills, called drumlins,



ODM7452

Photo 29–Varved clay in the Don Valley pit of Toronto Brick Company Limited.

that are caused by over-riding of ice where the till is thick. Terminal moraines are rough topographic areas composed of thick deposits of glacial debris that mark a lengthy stand of the ice-front in one position. In addition to till, other features of terminal moraines include kames—partly sorted and irregularly stratified hills of sand and gravel; outwash deposits—nearly level plains of sand and gravel that slope gently away from the former ice-front; and kettles—depressions formed by ice-blocks trapped in outwash deposits and subsequently melted.

Other glacial features include spillways—former river channels now represented by stratified deposits of sand and gravel—and their associated fan and delta deposits. Eskers are sinuous ridges of sand and gravel marking the former courses of subglacial rivers. Well-sorted and stratified sand and gravel occur as beach deposits, marking the shorelines of former glacial lakes.

STONELESS DEPOSITS

Glacial debris carried into lakes by streams originating on melting ice-sheets or on previously deposited till plains is commonly laid down on the lake beds as fine-grained deposits uncontaminated by pebbles. Stoneless deposits of clay, silt, or fine sand laid down in relatively quiet waters are usually stratified due to variations in texture, colour, and composition. In Ontario, stratified clays can be recognized as varved clays, non-varved lake clays, interglacial clays, marine clays, or flood plain clays. Also essentially-stoneless are certain unstratified clays locally developed in till.

VARVED CLAYS

Varved clays are widespread in Ontario, where they are the most typical fine-grained deposits of glacial lakes. Varved clay deposits consist of seasonal layers of clay and silt—the clay layer representing

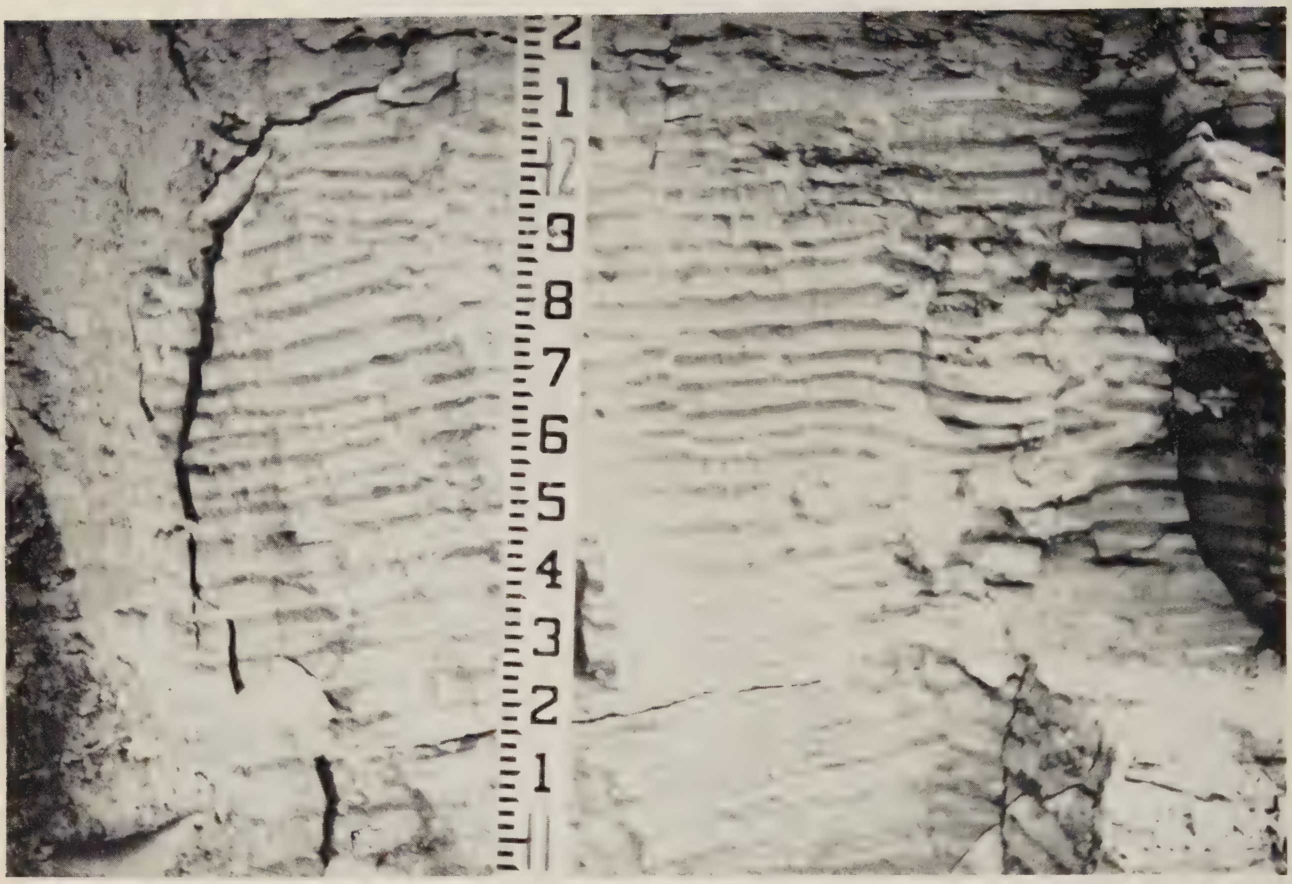


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Photo 30—Close-up of the varved clay in the pit of Paisley Brick and Tile.

winter deposition, the silt layer summer deposition—each clay and silt couplet being one year's accumulation. Clay layers are homogeneous, smooth, dense, usually dark-coloured, and of uniform thickness; they were deposited in quiet water when the lake was frozen over. Silt layers are porous, light-coloured, and more variable in thickness than clay layers. Silt layers are sometimes finely laminated within themselves, the paper-thin laminae varying in grain size or colour, tracing the history of flood and storm throughout the summer season. Clay layers commonly range to 1 inch in thickness, silt layers to 3 inches.

A varve is a clay-silt couplet representing one year's deposition in the same way as a ring represents the annual growth of a tree. The upward transition from the silt layer to the clay layer is gradational, representing gradually reduced water flow during the fall freeze-up. More abrupt is the upward transition from the clay layer to the silt layer of the next varve, which represents the sudden surge of flow attendant with the spring break-up. Varves are usually thickest and siltiest at the base of the clay section, where they were deposited close to the melting ice-front. They become progressively thinner, but relatively more clayey, towards the top of the section as the ice-front, the source of the silt and clay, gradually retreats. Rounded pebbles are found in varved clays at wide intervals; they are believed to have been rafted on melting ice-blocks floating on the glacial lake. Because of the severity of the climate at the time of

TABLE 91 Varved Clays used for Brick and Tile

Basin of Deposition	Company and Pit Location
Local Ponding	N. S. Bauman Ltd., Wallenstein
	Booth Brick Ltd., Weston
	Toronto Brick Co. Ltd., East York
Lake Warren	Brantford Clay Products, Brantford
	Paisley Brick and Tile, Paisley
Lake Iroquois	Napanee Brick and Tile, Napanee
Lake Algonquin	Gomoll Brick and Tile, Powassan
	Gravell Brick Co., North Bay
	Home Brick Ltd., Bracebridge
	Huntsville Brick, Huntsville
	Superior Brick and Tile, Fort William

varve deposition, fragments of vegetation and shells are absent.

The theory of varve deposition is extensively given by Antevs (1925, pp. 23–44) and Flint (1957, pp. 294–295). The formation of varves appears to be closely related to the density of the lake waters, which is a maximum at about 39°F; water at this temperature tends to sink, displacing upwards water that is either warmer or colder. Sediment-laden waters fresh from the melting glacier are probably colder and less dense than the bottom layer of water in the lake. Silt and sand-sized particles are readily deposited, but it may be that suspended clay particles are prevented from deposition until the inflow of fresh water is sufficiently reduced by winter freeze-up to permit equalization of lake water temperatures.

Milligan, Soderman, and Rutka (1962) discuss the physical and engineering properties of varved clays and outline case histories of specific problems at a number of construction sites in Ontario.

Varved clays were deposited in the lakes and ponds that formed along the front of the receding Wisconsinan glacier. Varved clays deposited by all the major glacial lakes—Whittlesey, Warren, Iroquois, Algonquin, Agassiz, and Barlow-Ojibway—are exposed in river banks or on the flanks of bedrock and morainic hills. Eleven brick and tile plants in Ontario use varved clay for at least part of their raw material requirement (see Table 91).

NON-VARVED LAKE CLAYS

Non-varved clays are stratified deposits that have accumulated on lake beds where the water temperature was somewhat more moderate than that necessary for the formation of varves. Such clays are being deposited in the Great Lakes today, but they were also deposited both before and during the Wisconsinan glacial stage. Although varved clays are the most typical of glacial conditions, stratified clays may have formed instead when the ice-front had retreated some distance from the basin of deposition or when warmer waters were entering the lake from another source. Stratified clays may be rhythmically layered in coarse and fine particles, reflecting seasonal changes in the carrying power of the streams entering the lake, but the layers are much less uniform in relative composition and thickness than in varved clays.

TABLE 92 Non-varved Lake Clays used for Brick, Tile, or Sewer pipe

Basin of Deposition	Company and Pit Location
Local Ponding	Amos C. Martin Ltd., Wallenstein Bruce Brick and Tile Co., Teeswater
Pre-Lake Whittlesey	Rudolph Bittmen Tile Yard, Strathroy* D. A. Janes and Son Ltd., Delaware Rydall Brick and Tile Ltd., Elginfield
L. Whittlesey or Warren	Emig Clay Products Ltd., Chatham
Lake Warren ?	Deller's Tile Ltd., Brownsville Norwich Brick and Tile Ltd., Norwich
Lake Warren	Brantford Clay Products Ltd., Brantford Kitchener Brick Co., Ltd., Brantford Amos C. Martin Ltd., Parkhill Parkhill Brick Co. Ltd., Parkhill
Lake Iroquois	Canada Vitrified Products Ltd., Aldershot National Sewer Pipe Ltd., Aldershot
Lake Algonquin	Beaverton Brick and Tile Co. Ltd., Beaverton Elliott's Brickyard, Sault Ste. Marie
Early Lake St. Clair	Dresden Tile Yard Ltd., Dresden Earl Lindsay and Sons Ltd., Wallaceburg

*Closed 1963

Non-varved lake clays deposited near shore or near the mouths of the feed streams may contain lenses of sand and fine gravel due to beach or deltaic conditions. Fragments of wood, leaves, and pine needles, and fresh-water gastropod (snail) and pelecypod (clam) shells are sometimes found in non-varved deposits.

Seventeen plants in Ontario use non-varved lake clays in the manufacture of brick, tile, and sewer pipe; in eight of these plants the non-varved lake clay is blended with some other clay or shale (see Table 92).

INTERGLACIAL CLAYS

Interglacial clays are stratified clays distinguished from younger lake clays only by age determinations and faunal studies or by their position beneath glacial sediments. The occurrence of warm water shells and vegetative fragments in the clays are conclusive evidence of a non-glacial interval. Interglacial clays have been recognized only in the Toronto region and on the James Bay lowland (Terasmae and Hughes 1960b).

The interglacial clays of the Toronto region consist of the Don Beds, belonging to the Sangamon interglacial stage, and the Scarborough Beds, which occupy an uncertain position between the warm climate beds and typical Wisconsinan glacial deposits (Terasmae 1960, p. 31). They are exposed only in deep

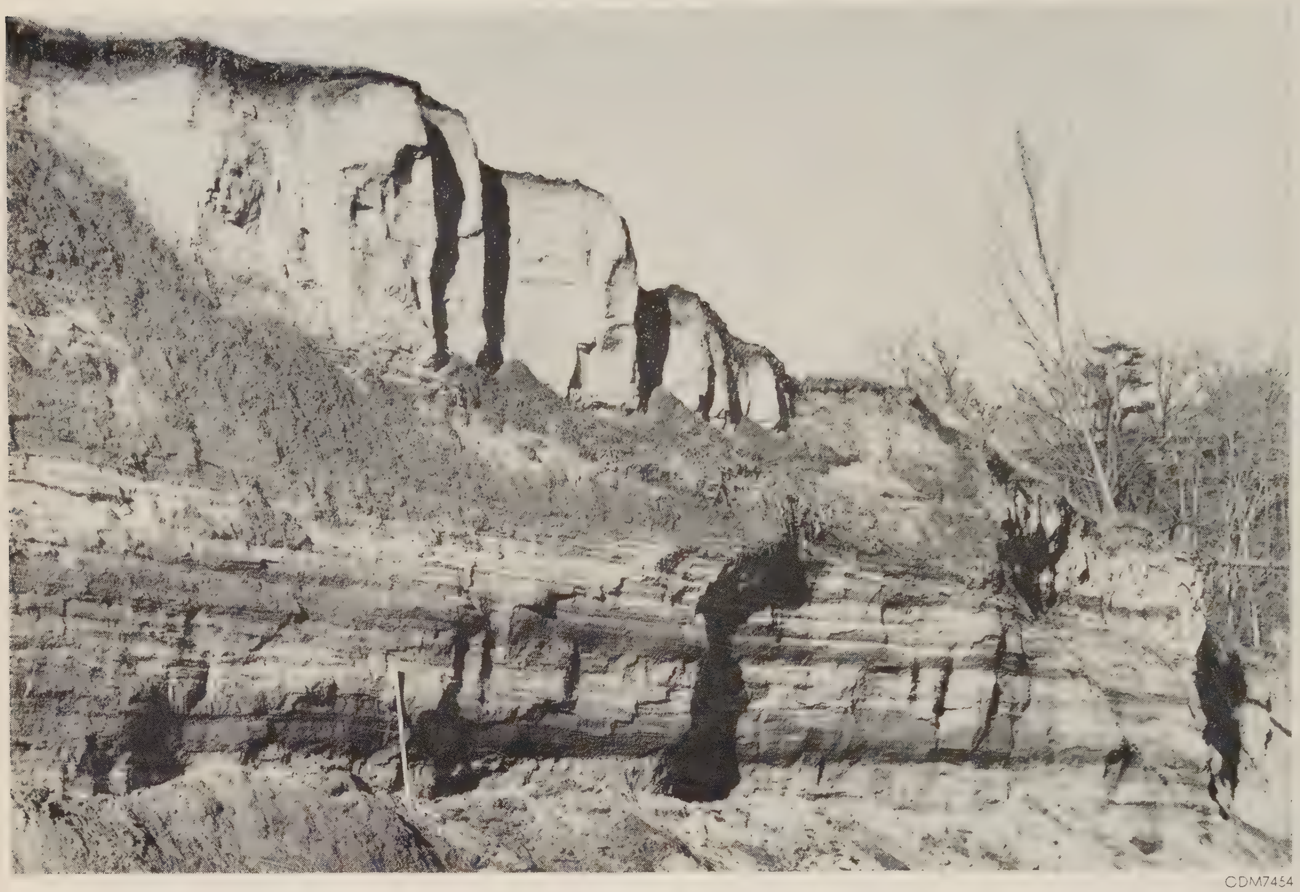


Photo 31—Scarborough and Don interglacial clays in the Don Valley pit of Toronto Brick Company Limited.

excavation or erosional cuts, such as Scarborough Bluffs and the Greenwood Avenue and Don Valley clay pits of Toronto Brick Company Limited. Scarborough Bed clay was formerly used by six brick plants on Greenwood Avenue (Keele 1924, p. 106), and until recent years was used by Toronto Brick Company Limited at both its Don Valley and Greenwood Avenue plants.

MARINE CLAYS

Marine clays are restricted in Ontario to the Ottawa-St. Lawrence River valleys and the James and Hudson Bay lowlands. They are stratified deposits of clay, silt, and sand, distinguished from other stratified deposits by the presence of marine shells and a moderate content of montmorillonite in the clay fraction. They were deposited in Ontario during the closing stages of the Wisconsinan glaciation, when the seas encroached on the depressed land surface behind the retreating ice.

Marine clays deposited from the Champlain Sea, which occupied the Ottawa and St. Lawrence valleys, are reported to be nearly 200 feet thick in the Ottawa area (Johnston 1917, p. 18). The sequence of stratified deposits in this area consists of a thin base of varved silt succeeded consecutively upwards by stratified marine clays, freshwater clay, and sand (Gadd 1963). The Dochart Brick and Tile Company Limited at Arnprior is the only plant in Ontario using marine clay.

FLOOD PLAIN CLAYS

Flood plain clays are thin accumulations of stratified silt and clay deposited on the low flat banks of rivers and streams during periods of flood. Typically they are Recent deposits consisting of reworked and redeposited clays, or the finer portions of tills, interlayered with fresh-water shells, wood fragments, and other plant debris.

Table 93 Flood Plain Clays Used for Brick and Tile

Company	Pit Location	Rivercourse
Elliott's Brickyard	Sault Ste. Marie	St. Marys River
J. H. Henderson	Henfryn	Middle Maitland River
F. W. Howlett and Sons Ltd.	Petrolia	North Sydenham River
Superior Brick and Tile Co. Ltd.	Rosslyn	Kaministikwia River

Flood plain clays are often a good source of clay for brick and tile because of improved properties, particularly through the removal of lime by leaching, attendant with reworking and weathering. Flood plain clays are a major source of raw material for four brick and tile plants in Ontario (see Table 93).

STONELESS TILL

Tills are unsorted mixtures of clay and rock fragments deposited directly by ice. Some tills are sufficiently stonefree to be used in the manufacture of brick and tile; others have been modified to an almost-stonefree condition by later events.

"Stoneless" tills are tough unstratified deposits of clay or silty clay, usually having a low content of rounded pebbles. Tile plants using these clays commonly employ rolls-type crushers equipped with travelling rakes to remove pebbles too large for the nip of the rolls. Rolls-type crushers are usually effective in reducing smaller pebbles to sizes less than ¼-inch.

Tills that have subsequently been covered by lake waters have sometimes been modified by gentle wave or current action to an almost-stonefree state in their upper few feet. Such is the case in much of Essex, Kent, and Lambton counties, where a till plain has been levelled and smoothed by long submergence beneath the waters of lakes Whittlesey and Warren. For some reason these lakes failed to leave stratified clay deposits, except in a few local areas (Chapman and Putnam 1951, p. 176), but the top of the till was sifted and partly sorted leaving the upper 2–3 feet practically stonefree.

Table 94 Brick or Tile Plants Using Stoneless Till

Company	Pit Location
B. Broadwell and Son	Kingsville
Canada Brick Ltd.	Streetsville
Central Tile Brick Corp. Ltd.	Belle River
Central Tile Brick Corp. Ltd.	Tilbury
Comber Tile Yard Ltd.	Comber
Dresden Tile Yard Ltd.	Dresden
Elliott's Brick and Tile*	Glenannon
Emig Clay Products Ltd.	Chatham
Fletcher Tile Ltd.	Fletcher
Hill Tile Ltd.	Stevenson
W. J. McFarlane and Sons Ltd.	Forest
St. Clements Tile Yard*	St. Clements

*Closed 1962.

Stoneless tills, and the stonefree top of stony tills, are used exclusively by seven tile plants in Ontario. They are also used with other clays or shales at three brick or tile plants, at Streetsville, Chatham, and Dresden (see Table 94).

Producers Using Clay

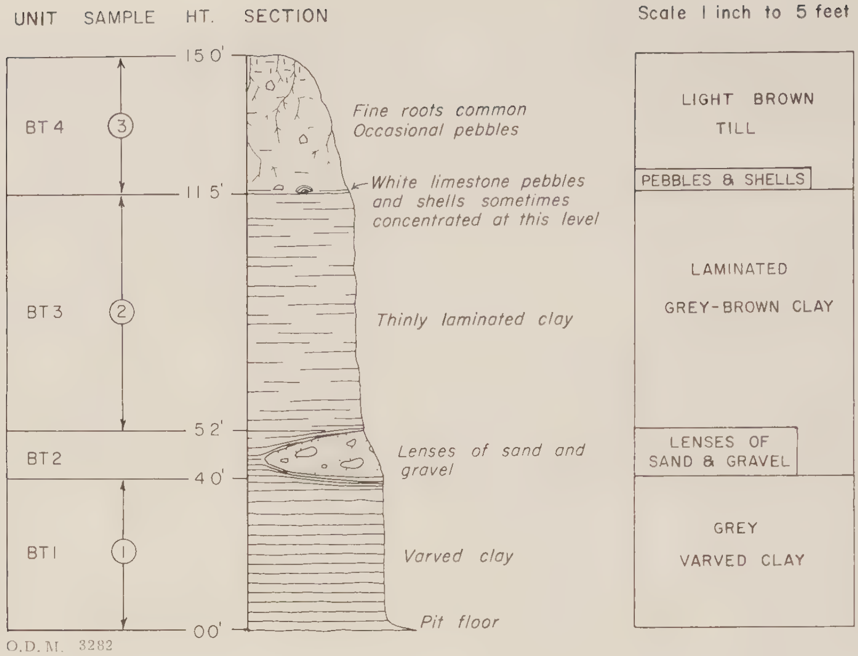
N. S. BAUMAN LIMITED

N. S. Bauman is manager of a tile plant on the south side of the county line near Wallenstein four miles west of Elmira. The plant was built in 1951. It is in lot 20, concession XIV, Wellesley township, Waterloo county.

Plant

Five million tile are produced annually in sizes from 4 to 16 inches. The operation is continuous throughout the year, and employs 40 men over-all (including 7 truckers).

Clay is dug from the bank by a Bantam gasoline dragline with a ½-yard bucket. Three dump trucks haul the clay about 1,000 feet to the plant where a fully enclosed stockpile sufficient for five months' continuous operation is built up during the summer months. It is reclaimed from storage by a Hough Payloader which loads a double-shaft pug feeder. The clay is fed to a belt which discharges through a 25-inch Parkhill disintegrator that effectively reduces the occasional small pebbles and kicks out any large ones. A Handle smooth double-roll crusher is closely set for reduction of the feed to minus ⅜ inch; each roll is 39 inches in diameter and has a 30-inch face. Clay is partitioned between two single-shaft pug mills by an adjustable baffle across the feed conveyor. Each pug mill discharges to a Plymouth Special auger machine operated at the rate of 1,800 tile per hour. All sizes of tile are extruded in a single stream under a vacuum of 18 inches. They are cut by F-R-H


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
15.0'
BT 4
③
Fine roots common
Occasional pebbles
LIGHT BROWN TILL
11.5'
White limestone pebbles and shells sometimes concentrated at this level
PEBBLES & SHELLS
BT 3
②
Thinly laminated clay
LAMINATED GREY-BROWN CLAY
5.2'
BT 2
Lenses of sand and gravel
LENSES OF SAND & GRAVEL
4.0'
BT 1
①
Varved clay
GREY VARVED CLAY
0.0'
Pit floor
O.D.M. 3282

Unit		Thickness (*feet*)
BT 4	Till: Mottled orange-brown to dark brown and green-grey; massive, porous, dry and crumbly; occasional white angular limestone pebbles; fine roots common.	3.5
BT 3	Clay: Medium-grey to olive-brown, drying light olive-grey; dense, plastic, stoneless; finely laminated (layers average ⅛-inch); irregular rusty streaks and mottlings.	6.3
BT 2	Sand: Lenses of grey to yellow-brown, fine- to medium-grained sand; scattered subangular pebbles to 8-inch; average ¾-inch.	1.2
BT 1	Clay: Medium-grey, drying light-grey; varved ⅛–⅜ inches; alternately dense, smooth, plastic clay, and light, porous, silt.	4.0

Figure 30—N. S. Bauman Ltd., pit section.

TABLE 95 Chemical Analyses: N. S. Bauman Limited

Sample	1	2	3	Composite	4
Height above floor (*feet*)	0.0–4.0	5.2–11.5	11.5–15.0	0.0–15.0	bulk
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				47.17	
Al_2O_3				10.5	
Fe_2O_3	3.80	4.00	5.75	4.80	4.48
CaO	18.6	17.7	2.12	13.6	2.12
MgO				4.48	
Na_2O				1.10	
K_2O				2.55	
TiO_2				0.62	
CO_2				12.46	
H_2O+				1.79	
H_2O-				1.48	
SO_3				0.25	
TOTAL				100.8	
Loss on ignition	18.85	18.17	5.83	16.09	6.62
Soluble salts	0.84	0.79	0.52		0.56

TABLE 96 Mineral Analyses: N. S. Bauman Limited
(A = abundant; B = moderate; C = minor; D = trace; ND = not detected)

Sample	1	2	3	Composite	4
Height above floor (*feet*)	0.0–4.0	5.2–11.5	11.5–15.0	0.0–15.0	bulk
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals					
Quartz	21	25	34	29	32
Calcite	22	24	ND	15	ND
Dolomite	17	13	ND	13	ND
Soda-lime feldspar	4	3	6	5	10
Potash feldspar	<0.5	1	1	2	ND
Amphibole	<1	<1	<1	<1	<1
Clay minerals					
Illite	B	B	B	B	A
Chlorite	B	C	B	C	B
Expanding minerals	ND	D	B*	C*	ND

*Montmorillonite.

TABLE 97 Ceramic Tests: N. S. Bauman Limited

SAMPLE 1: 0.0′–4.0′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	3.4
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0	0.4	0.5
Colour	tan	light tan	cream
Hardness	soft	soft	almost hard
24-hour absorption (%)	22.1	21.0	21.8
5-hour boil absorption (%)	22.6	22.5	25.8
Specific gravity	1.63	1.60	1.59

SAMPLE 2: 5.2′–11.5′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.0
Pyrometric cone equivalent	3–4

	Cones		
	(1660°F)	(1840°F)	(1980°F)
Lineal firing shrinkage (%)	0.2	0.2 expansion	0.4
Colour	tan	light tan	cream
Hardness	soft	soft	almost hard
24-hour absorption (%)	20.4	20.6	19.0
5-hour boil absorption (%)	21.3	22.2	23.0
Specific gravity	1.68	1.65	1.66

REMARKS: Clay tends to be flabby and to warp easily during drying and firing.

SAMPLE 3: 11.5′–15.0′

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	6.5
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	2.1	8.2
Colour	salmon	medium-red	dark red
Hardness	almost hard	very hard	very hard
24-hour absorption (%)	13.0	10.9	1.5
5-hour boil absorption (%)	13.9	12.0	1.8
Specific gravity	1.91	1.98	2.38

REMARKS: Briquettes are slightly warped and overfired at cone 03.

SAMPLE 4: bulk sample

Water of plasticity (*percent*)	28
Lineal drying shrinkage (*percent*)	7.6
Pyrometric cone equivalent	8

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5	1.8	6.1
Colour	salmon	dark salmon	medium red
Hardness	almost hard	hard	very hard
24-hour absorption (%)	13.9	11.9	3.8
5-hour boil absorption (%)	14.9	13.9	6.0
Specific gravity	1.85	1.90	2.18

cutters and hacked in two tiers, 192 per rack. Barrett electric platform lifts move them to the dryers.

There are five waste-heat room dryers, 120 by 24 feet, each holding some 29,000 tile. Heat is drawn from both top and bottom of the kilns during their cooling cycle. Tile are dried for seven days, but only the last three are on-heat. Peak drying temperature is 130°F. There are five beehive kilns with diameters of about 26 feet, each holding 23,000 to 27,000 tile. They are fired with number 4 or 5 bunker oil to a peak temperature of 1800°F, and are on-fire for a total of 50–55 hours. Turnover cycle is seven days. Burned tile are cream-coloured streaked with pink.

GEOLOGY

The clay pit is located a short distance back of the plant in a shallow topographic depression that opens southward towards the Conestogo River. The local terrain is flat and is dominated to the west and north by a thin mantle of till; low hills to the east are kames of sand and gravel flanked by an apron of outwash sand. At the pit, a thin remnant of the almost stone-free till overlies thinly laminated grey-brown clay and grey varved clay, and lenses of yellow outwash sand and fine gravel occur above the varved beds. The section is illustrated in figure 30 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are shown in tables 95, 96, 97.

In 1961, Mr. Bauman was also experimenting with clay from lot 7, concession XIII, Wellesley township, six miles from the plant. The deposit was being opened only to a depth of four feet, and like the top 3–4 feet at the main pit, the clay is weakly calcareous and contains occasional small white angular limestone pebbles. It is a mottled medium-grey to olive-grey, massive, slightly silty and porous till, containing numerous fine roots and a few rusty spots. The results of test work on a small bulk sample of this clay are given under sample 4 in Table 97.

BEAVERTON BRICK AND TILE

F. Taylor is the owner of a tile plant on the north side of the Beaverton River on the eastern outskirts of Beaverton. The plant is located in the north part of lot 13, concession V, Thorah township, Ontario county. Clay is obtained from adjoining lot 12, and the southern part of lot 10, concession V. Early descriptions of brick-making at Beaverton are given by Baker (1906, pp. 87–88), Keele (1924, pp. 76, 80), and Montgomery (1930, pp. 142–143).

Plant

The plant employs 14 men for the 9-month working season. About 1.7 million cream-buff drain tile are produced annually in 4-, 6-, and 8-inch sizes. Brick are occasionally made.

Clay is taken from the main pit in lot 12, by a John Deere tractor equipped with a ¾-yard front-end bucket. It is trucked 1,000 feet to a large open-air stockpile at the plant. The clay pit in lot 10 is the site of a former brick or tile yard. Clay is taken from the water-filled pit by dragline and is stockpiled on the bank. A John Deere "Crawler-Loader" No. 440, with a ½-yard bucket, loads two dump trucks for the 1½-mile haul to the plant. About five parts of the sandy brown clay from the near pit are mixed with one part of blue plastic clay from the more distant pit. A small amount of hydrated lime to take up excess moisture is added as required. A Ford farm tractor with a ⅓-yard rear-end bucket reclaims clay from the stockpile and dumps it into an 8-foot Parkhill single-shaft pug feeder. Clay is fed to a 20-inch double roll Parkhill disintegrator; then conveyed by a 17-inch belt to an F-R-H Plymouth Special de-airing auger machine. Tile are extruded in a single stream under a vacuum of 22 inches, and are cut by an F-R-H cutter. Production is 10,000 to 14,000 per day. The tile are hacked in three tiers, 200 per rack, and are transported to the dryers by gasoline-powered Truckman rack lifts.

Two waste-heat room dryers have a capacity of 63,000 tile, and a further 22,000 can be dried on open-air racks. Three beehive kilns have capacities of 18,000, 22,000, and 28,000 tile. They are normally fired by wood, sometimes coal, to a peak temperature of 1930°F, and are operated on a ten-day cycle. Mr. Taylor reports that his average fuel consumption is one cord of wood slab per 1,000 finished tile.

GEOLOGY

Stratified clay, sand, and silt deposited beneath the waters of glacial Lake Algonquin are found throughout the Lake Simcoe basin. The clay and sand section exposed in the two pits worked by Beaverton Brick and Tile reflect the waning stages of the lake. The No. 2 pit, in lot 10, concession V, Thorah township, shows the transition from grey plastic clay at the bottom, through laminated clay and silt, to stratified sand at the top; the sequence records the progressive change from deep-water conditions at an early stage to beach conditions as the lake level receded. The section at the main pit, lot 12, concession V, Thorah township, consists of stratified sand and silt resting on till, a sequence that reflects only shallow water and beach conditions. The two sections are illustrated in figure 31 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 98, 99, 100. A complete analysis of the lower grey plastic clay similar to that from No. 2 pit is taken from Baker (1906, p. 87).

TABLE 98 Chemical Analyses: Beaverton Brick and Tile

	Beaverton pit	Pit No. 2		
Sample	1	2	3	Baker (1906, p. 87)
Height above floor (*feet*)	0.0–7.0	bulk	0.0–7.0	
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				37.50
Al_2O_3				10.31
Fe_2O_3	3.03	3.87	3.85	3.59
CaO	15.1	24.7	25.2	22.56
MgO				2.61
Na_2O				1.11
K_2O				2.34
SO_3				0.12
Loss on ignition	13.06	20.53	21.24	19.60
Soluble salts	0.77	0.56	0.54	

TABLE 99 Mineral Analyses: Beaverton Brick and Tile (B = moderate; C = minor)

	Beaverton pit	Pit No. 2	
Sample	1	2	3
Height above floor (*feet*)	0.0–7.0	bulk	0.0–7.0
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	33	20	19
Calcite	26	39	36
Dolomite	5	4	2
Soda-lime	8	4	5
Potash feldspar	3	1	<0.5
Amphibole	<1	<1	0.5–5
Clay minerals			
Illite	B	B	B
Chlorite	C	C	C
Expanding minerals	C	C	C

TABLE 100 Ceramic Tests: Beaverton Brick and Tile

SAMPLE 1: Beaverton pit, 0.0′–7.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.5
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.8	1.2	1.2
Colour	tan	grey-buff	grey-buff
Hardness	soft	soft	moderately hard
24-hour absorption (%)		19.0	15.8
5-hour boil absorption (%)		26.0	25.0
Specific gravity		1.61	1.64

REMARKS: Briquettes are sandy-textured and weak. Briquettes fired at cone 010 crumbled on exposure to the air.

SAMPLE 2: Pit No. 2, bulk

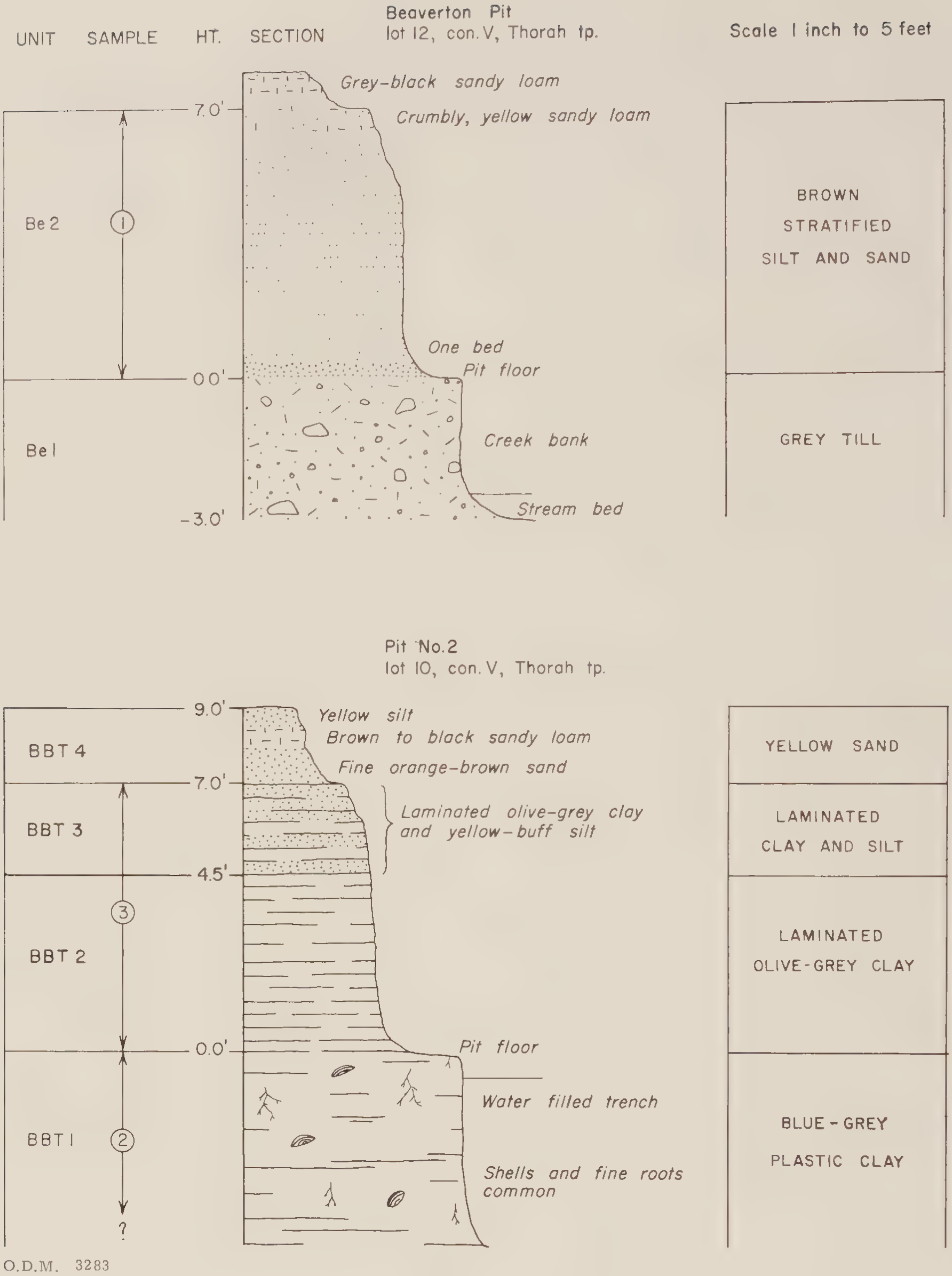
Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.9
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.9 expansion	3.2 expansion	0.4
Colour	light tan	cream	buff
Hardness	soft	soft	almost hard
24-hour absorption (%)	24.7	26.6	20.9
5-hour boil absorption (%)	25.8	28.7	25.2
Specific gravity	1.54	1.48	1.64

SAMPLE 3: Pit No. 2, 0.0′–7.0′

Water of plasticity (*percent*)	22
Lineal drying shrinkage (*percent*)	4.8
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.2 expansion	2.5 expansion	0.5
Colour	light tan	cream-buff	light yellow
Hardness	soft	soft	almost hard
24-hour absorption (%)	24.6	25.4	18.2
5-hour boil absorption (%)	25.4	27.7	24.2
Specific gravity	1.57	1.50	1.67


UNIT
SAMPLE
HT.
SECTION
Beaverton Pit
lot 12, con. V, Thorah tp.
Scale 1 inch to 5 feet
Grey-black sandy loam
Crumbly, yellow sandy loam
7.0'
Be 2
①
BROWN STRATIFIED SILT AND SAND
One bed
Pit floor
0.0'
Be 1
Creek bank
GREY TILL
-3.0'
Stream bed
Pit No. 2
lot 10, con. V, Thorah tp.
9.0'
Yellow silt
Brown to black sandy loam
Fine orange-brown sand
BBT 4
YELLOW SAND
7.0'
BBT 3
Laminated olive-grey clay and yellow-buff silt
LAMINATED CLAY AND SILT
4.5'
③
BBT 2
LAMINATED OLIVE-GREY CLAY
0.0'
Pit floor
Water filled trench
BBT 1
②
BLUE-GREY PLASTIC CLAY
Shells and fine roots common
?
O.D.M. 3283

Unit		Thickness (*feet*)
BEAVERTON PIT (lot 12, con. V, Thorah tp.)		
BE 2	SAND, SILT: Medium grey-brown, drying yellow-brown; stoneless; stratified ⅛–⅜ inches; rusty bedding planes and joints.	7.0
BE 1	TILL: Medium grey, drying light grey; silty, plastic, tough, massive; abundant rounded pebbles and cobbles to 4-inch.	3.0
PIT NO. 2 (lot 10, con. V, Thorah tp.)		
BBT 4	SAND, LOAM: Fine-grained orange-brown sand grading upwards to brown-black sandy loam and yellow silt; topped by sod.	2.0
BBT 3	CLAY, SILT: Olive-grey clay and buff-yellow silt; laminated ⅛–¼ inches; stoneless.	2.5
BBT 2	CLAY: Olive-grey, drying pale buff-grey; silty, stoneless, and plastic; irregularly stratified from 1/16-inch to several inches; dark brown organic mottling or stain on shrinkage cracks.	4.5
BBT 1	CLAY: Blue-grey, drying light grey; uniform, smooth, plastic; usually massive, sometimes finely (⅛-inch) laminated; stoneless; fine roots and ½-inch shells common.	20 ±

Figure 31—Beaverton Brick and Tile, pit sections.

RUDOLPH BITTMEN TILE YARD

A small plant a mile or so north of Strathroy was worked by Rudolph Bittmen and his family from 1946 to 1963. It was built in 1880 and has changed very little from the beginning. It is located in lot 24, concession II, Adelaide township, Middlesex county. Early references to this plant are given by Baker (1906, p. 79) and Montgomery (1930, p. 136). The plant has not been worked since 1963.

TABLE 101 Partial Chemical Analysis: Rudolph Bittmen Tile Yard

Sample	1
Height above floor (*feet*)	0.0–7.5
	(*percent*)
Fe_2O_3	5.33
CaO	5.43
Loss on ignition	19.12
Soluble salts	0.80

Plant

Mr. Bittmen and his wife, with the help of their son during school holidays, produced 150,000 tile in a 5- or 6-month season. Tile were made in 4-, 5-, 6-, and 7-inch diameters.

Sufficient clay was stockpiled once each year on a contract basis. The pit adjoins the plant, and a haulage distance of less than 100 feet was required. A Fordson Major rubber-tired front-end loader reclaimed clay from the stockpile. It dumped directly onto a wooden ramp and the clay was fed by hand-shovel through a discharge chute directly to the Baird machine. The combined Baird smooth roll and auger extruder was driven by a 40-horsepower Minneapolis Moline gasoline motor with belt drive. The tile stream was cut by a Hensing automatic cutter. Tile were hacked in two tiers 90 to 125 per car.

There were nine shed-covered open-air drying tracks 75 feet long, having a total capacity of 14,000 tile. Two beehive kilns of 22-foot inside diameters held 13,000 to 14,000 tile each and burned soft coal.

The buff-white tile were shipped by truck from yard storage.

TABLE 102 Mineral Analysis: Rudolph Bittmen Tile Yard
A = abundant; C = minor; ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–7.5
	(*percent*)
Non-clay minerals	
Quartz	20
Calcite	23
Dolomite	7
Soda-lime feldspar	3
Potash feldspar	2
Amphibole	ND
Clay minerals	
Illite	A
Chlorite	C
Expanding minerals	C

GEOLOGY

The pit occupies an area 300 feet square in gently rolling farmland that is underlain principally by brown calcareous silty till. A 7.5-foot section of bedded (1–3 inches) brown clay exposed in the pit indicates the former existence of an early glacial lake (probably pre-Lake Whittlesey). Bedding planes are barely obvious with veneers of yellow silt. The clay is dense, tough, and stoneless. It has a blocky weathering, but becomes crumbly or loamy in more massive clay at the top. The results of chemical, mineralogical, and ceramic testing of a vertical channel sample are contained in tables 101, 102, and 103.

TABLE 103 Ceramic Tests: Rudolph Bittmen Tile Yard

SAMPLE 1: 0.0′–7.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	5.5
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	0.4	1.0
Colour	tan	cream	buff
Hardness	hard	almost hard	very hard
24-hour absorption (%)	17.1	16.6	16.6
5-hour boil absorption (%)	17.8	18.8	21.2
Specific gravity	1.72	1.71	1.73

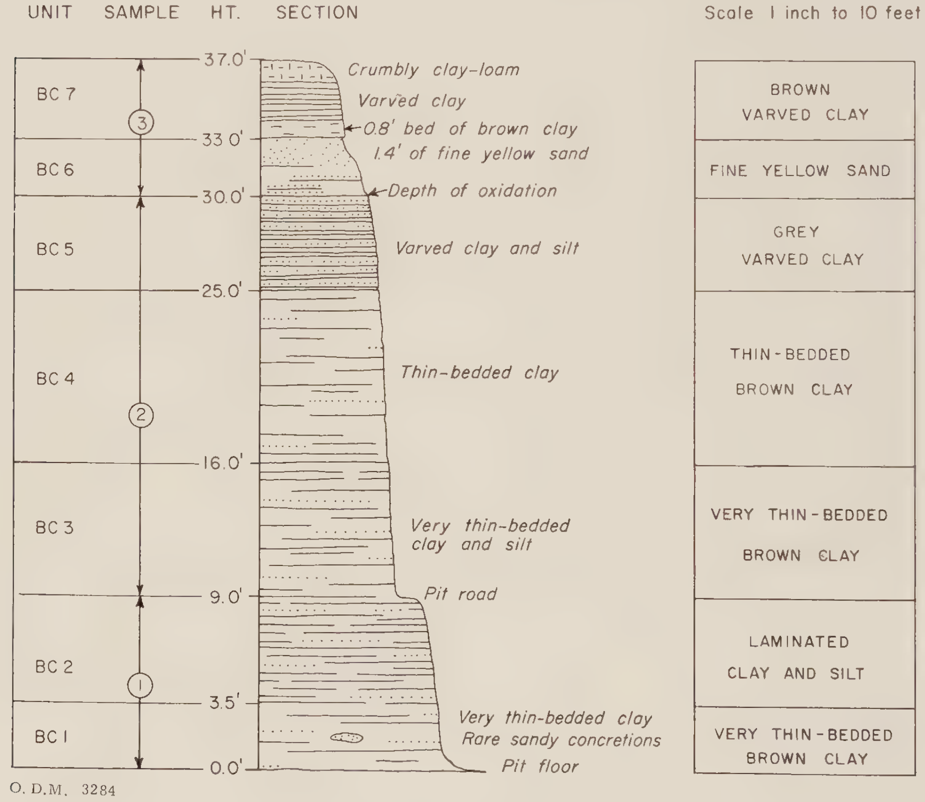
BRANTFORD CLAY PRODUCTS LIMITED

E. Biggar is the manager of a plant on the Newport Road beside the Grand River a few miles south of Brantford. The operation was started in 1951, but Mr. Biggar reports that tile had been made on this site 80 years ago. The plant is located in the Lafferty tract, Brantford township, Brant county. Clays and brick-making at Brantford are described by Baker (1906, pp. 58–59) and Keele (1924, pp. 94, 111).

Plant

The production is 1½ million drain tile in 4-, 5-, 6-, and 8-inch sizes during a 9½-month working season. Twelve men are employed.

Top and bottom clays are stockpiled separately by small Letourneau scrapers. A shed-covered area provides storage for 1,000 tons. An Oliver front-end loader batches the two clays in the proportion of two parts of the top clay to one part of the bottom blue clay and loads a Parkhill single-shaft pug feeder. An 18-inch Parkhill double-roll disintegrator discharges


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 10 feet
BC 7
BC 6
BC 5
BC 4
BC 3
BC 2
BC 1
3
2
1
37.0'
33.0'
30.0'
25.0'
16.0'
9.0'
3.5'
0.0'
Crumbly clay-loam
Varved clay
0.8' bed of brown clay
1.4' of fine yellow sand
Depth of oxidation
Varved clay and silt
Thin-bedded clay
Very thin-bedded clay and silt
Pit road
Very thin-bedded clay
Rare sandy concretions
Pit floor
BROWN VARVED CLAY
FINE YELLOW SAND
GREY VARVED CLAY
THIN-BEDDED BROWN CLAY
VERY THIN-BEDDED BROWN CLAY
LAMINATED CLAY AND SILT
VERY THIN-BEDDED BROWN CLAY
O.D.M. 3284

Unit		Thickness (feet)
BC 7	CLAY: Brown clay and pale yellow silt; stoneless; ½-inch varves; rusty joints and fractures; crumbly clay-loam top.	4.0
BC 6	SAND: Yellow sand and minor brown clay; fine-grained; stratified; stoneless.	3.0
BC 5	CLAY AND SILT: Medium-grey clay and pale grey silt; ¼–½-inch varves; stoneless; clay and silt in about equal proportions.	5.0
BC 4	CLAY: Dark mauve-brown clay and pale-grey silt; stratified in layers 1–4 inches thick, with a fine superimposed lamination consisting of many colour and textural variations; stoneless.	9.0
BC 3	CLAY AND SILT: Grey-brown to mauve-brown clay and pale-grey silt; stratified in layers ½–2 inches thick; some green and pink mottling; stoneless; clay predominates.	7.0
BC 2	CLAY AND SILT: Green-grey to mauve-brown clay and light-grey silt; stratified in ¾-inch layers; stoneless; clay and silt in about equal proportions.	5.5
BC 1	CLAY: Dark mauve-brown clay and pale-grey silt; stratified in layers ½–2 inches thick; some grey-green mottling; rare ⅜-inch pink-brown sandy concretions; clay predominates.	3.5

Figure 32–Brantford Clay Products Ltd., pit section.

TABLE 104 Chemical Analyses: Brantford Clay Products Ltd.

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–9.0	9.0–30.0	30.0–37.0	0.0–37.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				41.81
Al_2O_3				10.2
Fe_2O_3	3.84	4.05	3.77	4.05
CaO	19.0	19.4	19.0	19.6
MgO				2.90
Na_2O				1.10
K_2O				2.56
TiO_2				0.58
CO_2				14.49
H_2O+				1.96
H_2O-				0.67
SO_3				0.74
TOTAL				100.7
Loss on ignition	16.56	18.70	16.30	18.15
Soluble salts	0.37	0.56	0.64	

TABLE 105 Mineral Analyses: Brantford Clay Products Ltd. B = moderate; C = minor; ND = not detected)

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–9.0	9.0–30.0	30.0–37.0	0.0–37.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	22	17	24	26
Calcite	28	29	27	28
Dolomite	6	3	4	5
Soda-lime feldspar	4	4	7	6
Potash feldspar	2	ND	3	2
Amphibole	ND	ND	<1	<1
Clay minerals				
Illite	B	B	B	B
Chlorite	B	B	C	B
Expanding minerals	ND	ND	C	C

TABLE 106 Ceramic Tests: Brantford Clay Products Ltd.

SAMPLE 1: 0.0′–9.0′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	3.9
Pyrometric cone equivalent	3–4

	Cones 010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.2	0.5	0.5
Colour	tan	cream-buff	cream-buff
Hardness	almost hard	almost hard	almost hard
24-hour absorption (%)	19.7	20.3	19.8
5-hour boil absorption (%)	19.9	22.8	23.9
Specific gravity	1.68	1.65	1.67

SAMPLE 2: 9.0′–30.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.3
Pyrometric cone equivalent	3–4

	Cones 010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.5	0.3	0.3
Colour	tan	cream	light buff
Hardness	almost hard	almost hard	almost hard
24-hour absorption (%)	22.6	24.6	24.5
5-hour boil absorption (%)	23.7	26.5	27.1
Specific gravity	1.58	1.58	1.60

REMARKS: Briquettes are smooth-textured and attractive at cone 03.

SAMPLE 3: 30.0′–37.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.5
Pyrometric cone equivalent	3–4

	Cones 010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	0	0.9
Colour	dark tan	buff	yellow-buff
Hardness	hard	hard	hard
24-hour absorption (%)	18.8	18.5	16.8
5-hour boil absorption (%)	19.9	21.0	21.9
Specific gravity	1.71	1.69	1.74

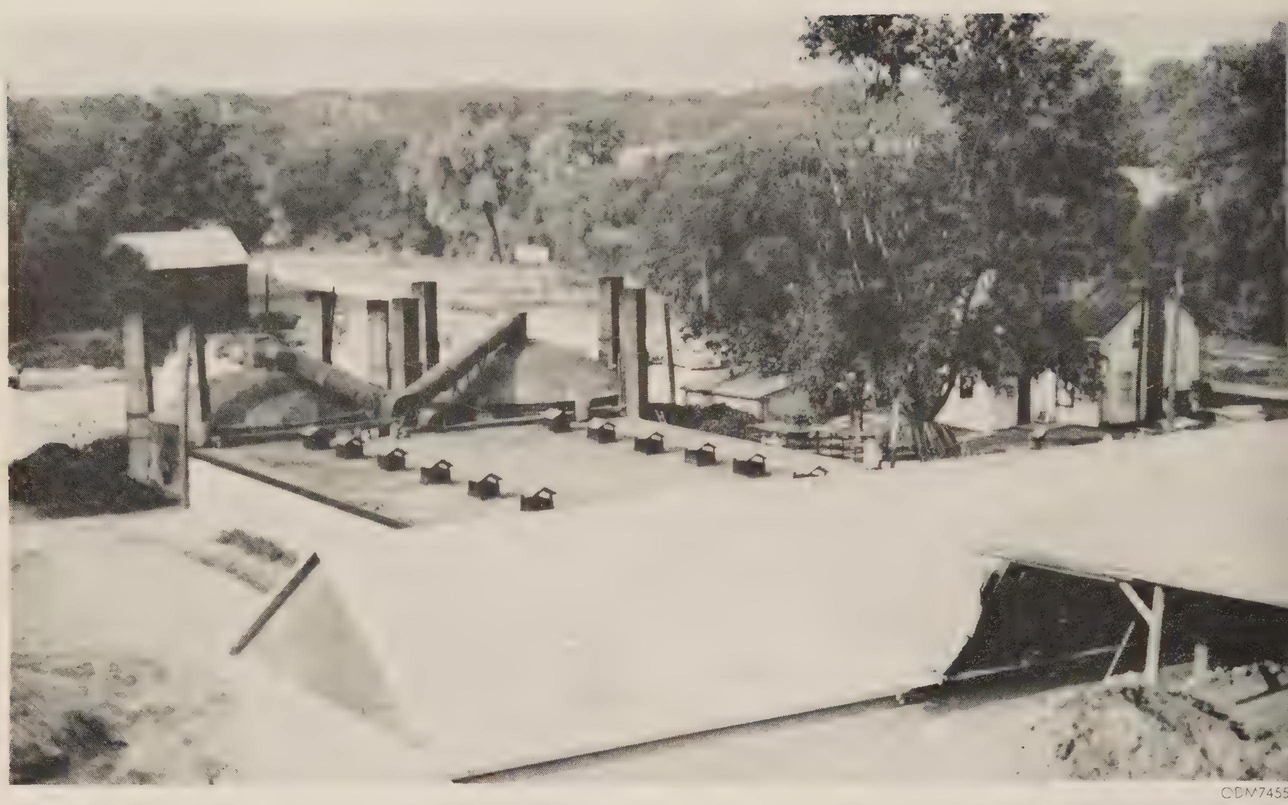


Photo 32—Brantford Clay Products Limited; plant 1961.

to a 17-inch belt conveyor which carries the clay to the extruder. Extrusion is performed by an F-R-H Hummer under a vacuum of 18 inches. The single stream is cut by a Frey Universal cutter and the tile are hacked in three tiers on iron racks. Truckman gasoline platform lifts move the loaded racks to the drying rooms.

There are three room dryers using waste heat collected from the crown of the kilns. Total capacity is 80,000 tile, and drying time is 60 hours at 120°–150°F. Two beehive kilns of 26- and 30-foot diameters hold 20,000 and 30,000 tile respectively. They are coal-fired to 1850°–1900°F and are kept on-fire for 72 hours. Under normal conditions it is possible to operate the kilns on a 7-day cycle.

GEOLOGY

At an early stage in the final retreat of the glacial ice from southern Ontario the Lake Erie basin was occupied by glacial Lake Warren. Ice in the Lake Ontario basin blocked the normal eastward drainage, so that the level of Lake Warren was raised until it overflowed to the west into the Mississippi River. At its maximum level the shoreline of Lake Warren extended up the Grand River valley to Brantford. Varved and laminated clay and silt were deposited. Figure 32 illustrates the 37-foot section exposed in the pit of Brantford Clay Products Limited. Descriptions of the clay, and the results of chemical, mineralogical, and ceramic testing of vertical channel samples, are given in the accompanying notes and tables 104, 105, and 106. Mr. Biggar reports (personal communication) that a further 30 feet of dense blue clay extends below the pit floor.

B. BROADWELL AND SON

One of the oldest tile yards under the same family ownership is that of B. E. Broadwell and Son of Kingsville. The plant is located in lot 12, concession IV, South Gosfield township, Essex county. Established about 1870 the operation has only slightly changed since the beginning. It is presently managed by the fourth generation of the Broadwell family

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Photo 33—B. Broadwell and Son; plant 1965.

Montgomery (1930, p. 115) gives an early description of the plant.

Plant

The plant employs 7 men for a 7- or 8-month season. Close to 300,000 drain tile and 100,000 brick are produced in an average year. The buildings are of wood construction, old but well-maintained. An International 65 h.p. stationary engine provides belt-drive for all equipment, replacing the original steam engine.

Clay is dug from the bank by a 1-yard Cockshutt front-end loader and hauled about a mile to the plant. It is dumped directly to a Bectel single-shaft pug feeder where tempering water is added. A 16-inch conveyor belt discharges the clay to a set of 10-inch diameter, 18-inch, spiral rolls which effectively eliminate pebbles larger than 1 inch. The clay drops to a set of 19-inch diameter, 16-inch, Baird smooth rolls set at 3/16-inch spacing, discharging directly to a Brewer single-stream auger machine. The stream is cut by a Bectel wire-cutter.

Two double-deck air drying sheds, 185 feet long by 25 wide, have a capacity of 100,000 tile. A single beehive kiln, 36 feet in inside diameter, holds 40,000 tile or 120,000 brick. The kiln is fired by coal to about 1750°F and is held on fire for 7 days. Turnover cycle is about three weeks, permitting the production of ten to twelve kilns per season.

Like others in Essex and Kent counties the Broadwells have been experimenting with perforated tile for improved drainage. They will now supply tile with three double-rows of perforations on request. The orange-red tile are stored in the yard and delivered by truck.

GEOLOGY

Clay is obtained near the north end of lot 12, concession V, South Gosfield township, about 1 mile north of the plant. Excavation to a depth of three feet has been carried out over an area 200 feet square. A 2.8-foot section was sampled. The top 12″ consists of tough grey-black loamy topsoil. Smooth, plastic, olive-grey clay underlies the topsoil. It has a blocky, massive texture, and is mottled with rusty-brown markings. Angular white limestone pebbles, generally less than ¼-inch, and rounded Precambrian fragments up to 1 foot in diameter, are occasionally present near the base of the section. Stone content shows a marked increase below a depth of three feet. The results of chemical, mineralogical, and ceramic testing of a vertical channel sample are given in tables 107, 108, 109.

TABLE 107 Partial Chemical Analysis: B. Broadwell and Son

Sample	1
Height above floor (*feet*)	0.0–2.8
	(*percent*)
Fe_2O_3	5.47
CaO	1.65
Loss on ignition	9.46
Soluble salts	0.81

TABLE 108 Mineral Analysis: B. Broadwell and Son
(A = abundant; C = minor; ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–2.8
	(*percent*)
Non-clay minerals	
Quartz	41
Calcite	ND
Dolomite	ND
Soda-lime feldspar	3
Potash feldspar	1
Amphibole	ND
Clay minerals	
Illite	A
Chlorite	C
Expanding minerals	C

TABLE 109 Ceramic Tests: B. Broadwell and Son

SAMPLE 1: 0.0′–2.8′

Water of plasticity (*percent*)	28
Lineal drying shrinkage (*percent*)	6.6
Pyrometric cone equivalent	11

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.2	4.8	7.6
Colour	salmon	salmon	dark salmon
Hardness	very hard	very hard	very hard
24-hour absorption (%)	12.0	5.3	1.1
5-hour boil absorption (%)	13.2	7.0	1.9
Specific gravity	1.93	2.15	2.34

REMARKS: Briquettes are attractive and undeformed throughout the firing range.

BRUCE BRICK AND TILE COMPANY

Bruce Brick and Tile Company opened a new plant in July 1963 on the site of an earlier tile yard. The company is owned by Gaitwin Explorations Limited. The plant is located in lot 20, concession XIV, Culcross township, Bruce county, about 5 miles north of Teeswater. The earlier plant is described by Montgomery (1930, p. 110) under the name of T. G. Donaldson.

Plant

The plant produces 1 million tile, 4–8 inches in diameter, during a 7-month season. A few Roman and Standard brick are also made. Ten men are employed during the season.

Digging and hauling of the clay is done by contract. A ½-yard Hanson backhoe loads two dump trucks for the 1,000-foot haul to the plant. The main part of the plant is a steel-frame Butler building, and the raw clay storage section occupies an area of about 50 by 70 feet at one end. Clay is reclaimed by a John Deere front-end loader that delivers the clay to a 36-inch set of smooth conical rolls. Discharge from the rolls is conveyed by belt to an E. M. Freese auger extruder. Water is added for tempering the clay; de-airing is not used. The single tile stream is cut by an F-R-H cutter, and the tile are hacked on platform racks in 3 tiers, 231 per rack.

Four waste-heat room dryers hold 12,000 tile each; the tile are dried for 3–4 days at 120°F. Three iron-clad round downdraft kilns, with diameters of about 26 feet, hold 24,000 tile each. The kilns are shed-covered and oil-fired. The burning process takes about 80 hours, and peak temperatures are 1850°F at the top of the kiln, 1600°F at the bottom. Truckman platform trucks carry the dry tile to the kilns for manual setting.

The buff tile are sometimes streaked with pink. The finished tile are loaded on trucks directly from the kiln, or stored in the yard.

GEOLOGY

A shallow deposit of silty brown clay underlies the southern part of the Greenock swamp. The clay was probably deposited from a small melt-water lake occupying the swamp basin during the final retreat of the Wisconsinan ice-sheet. The pit of the Bruce Brick and Tile Company occupies an irregular area 1,000 feet southwest of the plant. A 6–8 foot face exposes

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Photo 34–Bruce Brick and Tile Company; kilns 1965.

TABLE 110 Partial Chemical Analyses: Bruce Brick and Tile Company

Sample	1: Brick clay	2: Tile clay
Height above floor (*feet*)	0.0′–4.0′	0.0′–4.0′
	(*percent*)	(*percent*)
Fe_2O_3	3.10	4.39
CaO	18.9	10.3
Loss on ignition	20.63	13.74
Soluble salts	0.75	0.94

TABLE 111 Mineral Analyses: Bruce Brick and Tile Company (A = abundant; B = moderate; C = minor; D = trace; ND = not detected)

Sample	1: Brick clay	2: Tile clay
Height above floor (*feet*)	0.0′–4.0′	0.0′–4.0′
	(*percent*)	(*percent*)
Non-clay minerals		
Quartz	20	22
Calcite	18	6
Dolomite	19	8
Soda-lime feldspar	3	3
Potash feldspar	<0.5	1
Amphibole	ND	<1
Clay minerals		
Illite	B	A
Chlorite	C	B
Expanding minerals	D	B

TABLE 112 Ceramic Tests: Bruce Brick and Tile Company

SAMPLE 1: 0.0′–4.0′ "Brick clay"

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.5
Pyrometric cone equivalent	6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2	0.5 expansion	0
Colour	pale salmon	cream-pink	buff-white
Hardness	soft	moderately hard	almost hard
24-hour absorption (%)	23.6	24.4	22.0
5-hour boil absorption (%)	26.3	27.0	26.8
Specific gravity	1.55	1.54	1.55

REMARKS: Briquettes are well-fired and attractive at cone 03.

SAMPLE 2: 0.0′–4.0′ "Tile clay"

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	6.5
Pyrometric cone equivalent	4–5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.4	0.9
Colour	salmon	pale salmon	dark pink
Hardness	moderately soft	almost hard	hard
24-hour absorption (%)	16.8	16.5	13.6
5-hour boil absorption (%)	18.4	18.9	16.8
Specific gravity	1.75	1.75	1.78

REMARKS: Briquettes fired at cone 03 are mottled pink and buff.

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Photo 35—Canada Vitrified Products Limited; plant 1963.

brown clay, thinly stratified at the base, resting on "blue" limy clay. The limy clay is not used; it was reported (Bruce Maxwell, personal communication) to be 3 feet thick and to be underlain by gravel. The brown clay is massive near the top, and is mottled in shades of yellow, grey, buff, and blue. Small rounded stones are rare.

In 1961 two samples were taken a short distance south of the old plant. Sample no. 1 is a 4-foot vertical channel sample of buff-burning clay from the early "brick pit." Sample no. 2 is also a 4-foot sample; it is representative of a pink-firing clay from the "tile pit," 300 feet south of the first area. The results of chemical, mineralogical, and ceramic testwork are reported in tables 110, 111, 112.

CANADA VITRIFIED PRODUCTS LIMITED

Canada Vitrified Products Limited makes sewer pipe and flue linings at its plant on the eastern outskirts of St. Thomas, Yarmouth township, Elgin county. Formerly the plant used fireclay and shale from Ohio exclusively, but Aldershot red clay is now used with the imported materials.

Plant

Sewerpipe are commonly made in diameters of 4–12 inches, and occasionally to 18 inches, in lengths of 2, 3, 3½, and 4 feet. Flue linings are made in various sizes from 8½ by 8½ to 24 by 24 inches. Forty persons are employed the year round.

Clay arrives at the plant by rail and truck, and is stored in a covered shed of 10,000 square feet floor area, 28 feet high at the peak. A travelling conveyor beneath the peak facilitates separate or blended storage. The raw materials are reclaimed by front-end loader and fed to a 9-foot diameter drypan. Discharge from the drypan is elevated to a steel storage bin, from which two Stevenson 9-foot diameter wet pans are fed by gravity.

Two forming machines receive the prepared clay from the wet pans. Press no. 1 is a vertical hydraulic press used for large pipe and all flue linings. Press no. 2 is a Bradley and Craven auger press used for small fittings. The pipe are trimmed manually and hacked vertically on wooden pallets, forty-five 4-inch pipes per pallet. An F-R-H Junior double-shaft pug de-airing auger extruder is used for 4-, 6-, and 8-inch pipe. Extrusion by a timed intermittent cycle produces bell-end pipe at the rate of 360 per hour (4-inch diameter, 3-foot pipe). Plain-end pipe are made by continuous extrusion with automatic trimming. They are hacked as before. Pallets are moved by Truckman lifts to a large holding room.

There are six room dryers, 24 by 80 feet, using waste heat augmented by gas. Eight round downdraft kilns, each about 30 feet in diameter, are gas-burning. Each kiln is equipped with 10 gas burners, and a common stack serves each group of 4 kilns. Peak firing temperatures are 1900–2000°F and the burning period is 40–60 hours. Each kiln holds about 50 tons of ware and is turned over on an 8-day cycle.

GEOLOGY

To supplement imports of fireclay and shale from Ohio, red clay is obtained from the Aldershot pits of National Sewer Pipe Limited. The red clay is described in the section dealing with National Sewer Pipe Ltd. (p. 175–180).

CENTRAL TILE BRICK CORPORATION LIMITED, BELLE RIVER

This plant is located on the north side of the Canadian Pacific Railway tracks just south of the town of Belle River in lot 2, concession I, Rochester township, Essex county. It was built about 1923, has changed ownership several times, and is now owned by J. B. Emig of Chatham. Mr. Emig also owns a plant in Tilbury under the same name, and the Emig Clay Products plant in Chatham. Montgomery (1930, pp. 117–118) gives an early description of the Belle River operation.

Plant

The plant operates for about six months of the year, depending on business, and employs 19 men. It produces about 1½ million drain tile annually in all sizes from 4- to 12-inch. A large part of the company's market was in Michigan, but the lull in the construction industry in the late 1950's caused many Michigan brick plants to turn to tile manufacture, with a consequent loss to Canadian business.

Clay is dug from the bank with a ⅜-yard Hanson gas shovel and hauled by truck almost a mile to the plant. It is dumped directly to a 4-shaft Rust clay feeder and conveyed by an 18-inch belt to a set of smooth-faced rolls equipped with a manually operated rake to remove large stones. The extruder is an F-R-H double-shaft machine without de-airing. It is operated in a double stream on 4-inch tile, but single stream for 5-inch and larger. Cut-off is by a Fate wire-cutter, and the tile are hacked 140 to a car.

A 13-tunnel waste-heat dryer can accommodate 13 cars in each tunnel for a total of 23,600 tile. Drying time is 36 hours and temperature at the hot end is about 225°F. Larger tile can be dried in a room above the tunnels. Six beehive kilns of 27-foot inside diameters have a capacity of 22,000 tile each. They are coal-fired to a peak temperature of 1750°–1800°F and are on fire for 120 hours. Production averages three kilns per week.

Like the other plants in Essex county, this plant will produce tile with two double rows of perforations for improved drainage. The orange-red tile are stored in the yard and shipped mostly by truck.

TABLE 113 Partial Chemical Analysis: Central Tile Brick Corp. Ltd.

Sample	1
Height above floor (*feet*)	0.0–4.0
	(*percent*)
Fe_2O_3	6.05
CaO	1.68
Loss on ignition	7.64
Soluble salts	0.65

TABLE 114 Mineral Analysis: Central Tile Brick Corp. Ltd. (A = abundant; C = minor; ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–4.0
	(*percent*)
Non-clay minerals	
Quartz	36
Calcite	ND
Dolomite	ND
Soda-lime feldspar	<0.5
Potash feldspar	<0.5
Amphibole	ND
Clay minerals	
Illite	A
Chlorite	C
Expanding minerals	C

TABLE 115 Ceramic Tests: Central Tile Brick Corporation Limited

SAMPLE 1: 0.0′–4.0′

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	6.6
Pyrometric cone equivalent	9

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.2	5.4	6.6
Colour	salmon	dark salmon	dark red-brown
Hardness	very hard	very hard	very hard
24-hour absorption (%)	11.9	5.3	0.2
5-hour boil absorption (%)	13.0	6.1	0.3
Specific gravity	1.93	2.17	2.30

REMARKS: Briquettes are overfired but only slightly deformed at cone 03.

GEOLOGY

The clay pit is located at the east end of lot 2, concession I, Rochester township, about 1 mile from the plant. Sod is removed by harrowing, and the clay can be excavated to a depth of 4 feet before stones become numerous. Six inches of grey-brown clay-loam overlie rusty-mottled olive-grey clay. The clay is tough, moderately plastic, and silty. Angular limestone and round Precambrian pebbles are only occasionally found above the floor level, but fine roots are common. The results of chemical, mineralogical, and ceramic testing of a 4-foot vertical channel sample are given in tables 113, 114, 115.

CENTRAL TILE BRICK CORPORATION LIMITED, TILBURY

The Tilbury plant of Central Tile Brick Corporation Limited is located on the north side of Highway no. 2 just east of the main street of Tilbury, in concession IV, Tilbury East township, Kent county. An early description is given by Montgomery (1930, pp. 126–127). In recent times the plant has not operated every year; its production is integrated with that of the Belle River plant and the Chatham plant of Emig Clay Products Limited.

Plant

The Tilbury and Belle River plants are closely similar. Both plants employ 19 men, and produce about 1½ million tile in the smaller sizes. Larger tile are made in the Chatham plant.

Clay is taken from a pit 1 mile north of the plant using a Hanson gasoline shovel and truck. The clay is dumped into a 4-shaft auger feeder and fed by belt to a pair of smooth-faced rolls. The Plymouth auger machine extrudes 4-inch tile in a double stream, larger tile in a single stream. All equipment is belt-driven from a single 100 h.p. electric motor. Tile are hacked 150 per car.

There are 17 dryer tunnels that hold 13 cars each. They use waste heat augmented by coal; drying time is 2 days at 200°F. The 6 beehive kilns are slightly smaller than the Belle River kilns, and hold 18,000 tile each. They are coal-fired for 90–100 hours. Production at peak output is 3 kilns per week.

Tile can be made with one double row of perforations.

GEOLOGY

Clay is obtained from a pit 1 mile north of the plant. It is a red-burning clay similar to that used by other plants in Essex and Kent counties. Like the other deposits it is a till, essentially stonefree in its upper 3 feet.

COMBER TILE YARD LIMITED

The plant of Comber Tile Yard Limited is located on the south side of Highway no. 98 at the town of Comber, in lot 7, concession VI, Tilbury West township, Essex county. Russell Wright, the manager, is the third generation of the Wright family at this location. The plant was built in 1894 and was operated by D. Volkes until 1912. Early descriptions are given by Baker (1906, p. 63) and Montgomery (1930, p. 119).

Plant

The operation employs twelve men for an 8½- or 9-month season. Annual production averages 1,100,000 4-inch tile and 100,000 tile 5–8 inches in diameter.

Sod is stripped from the clay bank prior to digging with a Fordson Major Diesel back hoe. A similar machine equipped with a 1-year front-end bucket loads a small bottom-dump trailer. The ¼-mile haul to the plant is made with a standard Ford rubber-tired farm tractor. Clay is either stockpiled or discharged to a double-shaft pug feeder by way of an inclined chute from an overhead ramp. The clay passes through a set of 20-inch smooth rolls equipped with a mechanically operated rake for removing large pebbles. A 14-inch belt conveys the clay to a double shaft F-R-H Plymouth Special extruder. De-airing is accomplished at a vacuum of 20 inches. A double stream is used on 4-inch tile, a single stream for larger sizes. Cutting is by the standard Fate machine and the tile are hacked 150 per car.

Table 116 Chemical Analysis: Comber Tile Yard Limited

Sample	1
Height above floor (*feet*)	0.0–3.0
	(*percent*)
SiO_2	65.38
Al_2O_3	15.2
Fe_2O_3	5.75
CaO	1.10
MgO	1.38
Na_2O	0.64
K_2O	3.02
TiO_2	0.77
CO_2	0.68
H_2O+	3.59
H_2O-	1.92
SO_3	0.23
Total	99.7
Loss on ignition	6.66

Table 117 Mineral Analysis: Comber Tile Yard Limited
(B = moderate; C = minor;
ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–3.0
	(*percent*)
Non-clay minerals	
Quartz	45
Calcite	ND
Dolomite	ND
Soda-lime feldspar	3
Potash feldspar	1
Amphibole	ND
Clay minerals	
Illite	B
Chlorite	C
Expanding minerals	B*

*Vermiculite

Table 118 Ceramic Tests: Comber Tile Yard Limited

SAMPLE 1: 0.0′–3.0′

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	6.2
Pyrometric cone equivalent	10

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.9	0.9	6.1
Colour	salmon	dark salmon	salmon-brown
Hardness	very hard	very hard	very hard
24-hour absorption (%)	11.8	5.5	0.50
5-hour boil absorption (%)	13.0	7.0	0.76
Specific gravity	1.77	2.15	2.22

REMARKS: Briquettes are overfired but not deformed at cone 03.

ODM7459

Photo 36—Comber Tile Yard Limited; kilns 1965.

An 8-track waste heat tunnel dryer accommodates 15 cars on each track and is operated by manual push. Room dryers above the tunnels and along one side raise the total drying capacity to about 30,000 tile. Two beehive kilns with inside diameters of 26 feet hold 20,000 tile each. They are coal-fired to a temperature of 1800°F and are turned over on a 7-day cycle.

Shipments of the orange-red tile are made by truck from yard storage.

GEOLOGY

The clay deposit is similar to many others in Essex and Kent counties. Only the stonefree top few feet of a brown calcareous till is used. The top portion of the till has been partly re-sorted by the waters of lakes Whittlesey and Warren, but important amounts of new clay were not deposited in this area from these glacial lakes.

In 1961, clay was being taken from a shallow pit in low flat farmland ¼-mile south of the plant. The 3-foot section consists of olive-grey silty clay mottled with rusty brown and grey-blue. The clay is massive and tough, and contains a few rounded pebbles and fine roots. The top 6 inches is a grey-brown clay loam. Pebble content increases markedly below the 3-foot depth. The results of chemical, mineralogical and ceramic testing of a vertical channel sample are given in tables 116, 117, 118.

ODM7460

Photo 37—Deller's Tile Limited; plant 1961.

DELLER'S TILE LIMITED

E. Deller is the manager of a plant on the south side of Brownsville in lot 21, concession XI, Dereham township, Oxford county. The plant was built in 1904 and has been owned by the Deller family since 1922. Early descriptions are given by Baker (1906, pp. 86–87) and Montgomery (1930, p. 143).

Plant

Three million drain tile, mostly in the larger sizes (from 8- to 16-inch diameters), are made annually. The plant operates the year-round and employs 25 men.

A ½-yard gasoline Koehring No. 205 dragline loads the clay into trucks for the ¼-mile haul to the plant. A large open-air clay stockpile is built up at the plant during the summer months, sufficient to sustain the operation for a full year. An oil-heated 500-ton inside storage area provides clay during the severest weather. Clay is taken from storage by a 1½-yard Hough Payloader and dumped into a Parkhill single-shaft pug feeder. A bucket elevator feeds a set of 22-inch Brewer smooth conical rolls set at a ¼-inch gap. An 18-inch belt conveyor delivers the clay to a 36-inch diameter, 12-inch, Steele smooth rolls set at an opening of 1/16 inch. Occasional pebbles that may be present are sufficiently broken down in the grinding stage to be of little effect in the finished ware. A Parkhill single-shaft pug mill precedes extrusion by an F-R-H Plymouth Special auger machine operated at a rate of 2,200 tile per hour. De-airing is accomplished at 12 to 15 inches of vacuum. Three Fate cutters accommodate the different sizes of tile.

Tile are hacked in three tiers, 210 per rack, and moved to the dryers by three electric platform trucks. The two batch-dryers have two floors each and are approximately 10 by 60 feet and 80 by 40 feet in size. They have a total capacity of 100,000 four-inch tile or their equivalent. Drying time is two days at 105°F. Heat is reclaimed by a collector on the kilns but drying is augmented by gas and oil heating when required. Four beehive kilns of 25-foot diameters hold 50 tons (equivalent to 22,000 four-inch tile) of ware each. They are coal-fired to a peak temperature of 1800°F, and are turned over on a seven-day cycle. Under normal conditions the plant produces four kilns of burned ware per week.

GEOLOGY

In 1961 a clay pit was opened 1½ miles south of the plant in lot 21, concession XII, Dereham township. Excavation was carried to a depth of 23 feet. The blue-grey clay was actually a till with a low to moderate stone content; the upper 12 feet were oxidized to medium-brown.

TABLE 119 Chemical Analysis: Deller's Tile Limited

Sample 1: 6-foot section of brown clay	(*percent*)
SiO_2	48.68
Al_2O_3	12.19
Fe_2O_3	6.20
CaO	11.98
MgO	2.87
Na_2O	0.93
K_2O	2.63
TiO_2	0.51
CO_2	9.47
H_2O+	2.35
H_2O-	1.41
SO_3	0.22
TOTAL	99.4
Loss on ignition	13.66

TABLE 120 Mineral Analysis: Deller's Tile Limited (A = abundant; C = minor; ND = not detected)

Sample 1: 6-foot section of brown clay	(*percent*)
Non-clay minerals	
Quartz	28
Calcite	19
Dolomite	3
Soda-lime feldspar	4
Potash feldspar	1
Amphibole	ND
Clay minerals	
Illite	A
Chlorite	C
Expanding minerals	C

TABLE 121 Ceramic Tests: Deller's Tile Limited

SAMPLE 1: 6-foot section of brown clay

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	5.9
Pyrometric cone equivalent	2–3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	1.1	2.5
Colour	salmon	tan	tan
Hardness	hard	hard	very hard
24-hour absorption (%)	17.1	15.5	10.5
5-hour boil absorption (%)	17.6	16.4	11.0
Specific gravity	1.76	1.77	1.88

REMARKS: Smooth-textured attractive briquettes.

In 1962 a new pit was opened in a finely laminated lake clay ¼ mile west of the plant. In June 1965 this pit was 100 by 300 feet and 8 feet deep. The clay is tough and brown, mottled with rust and grey. Fine wavy laminations distinct at the bottom are less apparent towards the top. The clay is stoneless, and roots are scarce. Only the oxidized clay is used, and below the 8-foot depth the "blue" clay contains lenses of silt to several inches in thickness; the blue clay and silt burn to a porous and chalky body. The top 2 feet of the deposit consist of medium-grained yellow sand and black loamy topsoil; both are stripped and discarded. The results of chemical, mineral, and ceramic testing of a 6-foot vertical channel sample of the brown oxidized clay are shown in tables 119, 120, 121.

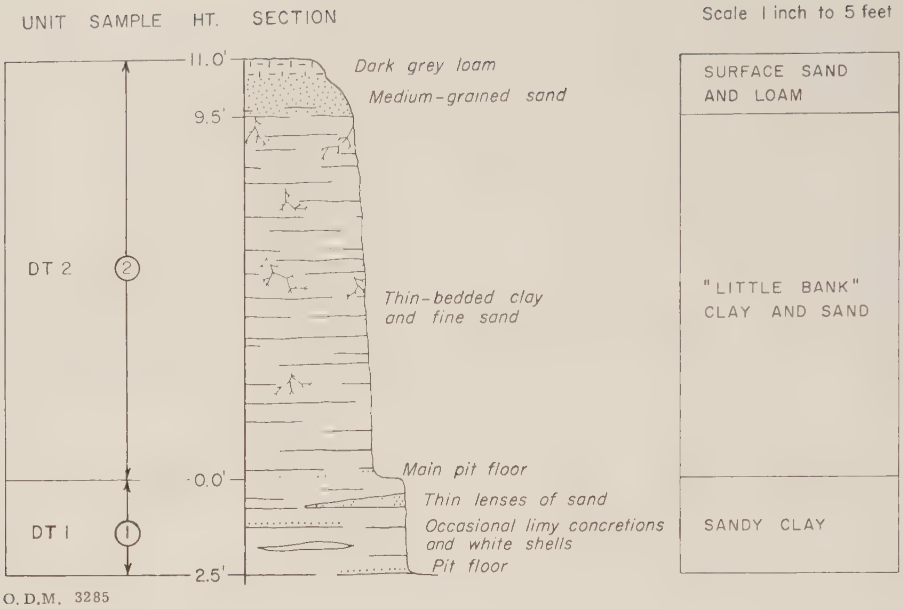
DOCHART BRICK AND TILE COMPANY LIMITED

J. S. McKay is the manager of a tile plant on the north side of Arnprior. It was built in 1868 and was operated until 1947 by the Baker family. The plant is located in lots 7 and 8, concession XIII, McNab township, Renfrew county. Early descriptions of the plant are given by Baker (1906, p. 96) and Montgomery (1930, pp. 152–153). Descriptions and properties of the clay are also given by Keele (1924, pp. 63, 65, 68).

Plant

Four million drain tile are produced during the 7-month working season and 36 men are employed. The bulk of production is in sizes of 4- to 10-inch diameter. Brick have not been made since 1946 but the soft-mud equipment is still available. A minor production of terra cotta has been maintained in recent years.

Clay is taken from the bank by front-end loader and hauled from the pit in 2-yard side-dump cars on rail, drawn by a Plymouth gas locomotive. Four to seven cars are hauled at at time on the semi-circular track. Distance to the plant is about 1,000 feet. The clay is discharged to a wood frame bin of 1,200 tons capacity and is drawn as required by bottom gate-discharge onto a belt conveyor. A large open-air stockpile is built up on the pit floor by bulldozer; it is covered by polyethylene during the winter and provides a source of dry clay for early spring operations. Clay from storage passes through a rolls disintegrator with ¼-inch discharge; then through a pair


UNIT SAMPLE HT. SECTION
Scale I inch to 5 feet
11.0'
9.5'
0.0'
2.5'
Dark grey loam
Medium-grained sand
DT 2
②
Thin-bedded clay and fine sand
Main pit floor
Thin lenses of sand
Occasional limy concretions and white shells
Pit floor
DT 1
①
SURFACE SAND AND LOAM
"LITTLE BANK" CLAY AND SAND
SANDY CLAY
O.D.M. 3285

Unit		Thickness *(feet)*
DT 2	CLAY: Olive-grey, drying buff; uniform, plastic, stoneless; stratified in 2-inch layers, clay grading downwards to fine sand; black organic and rusty stains on joint planes and cracks; fine roots common; topped by medium-grained yellow sand and dark grey loam.	11.0
DT 1	CLAY: Clay as above, with occasional thin lenses of fine sand; hard light-grey limy concretions and white shells are widely scattered.	2.5

Figure 33—Dochart Brick and Tile Co. Ltd., pit section.

TABLE 122 Chemical Analyses:
Dochart Brick and Tile Company Limited

Sample	1	Little Bank 2	Big Bank 3
Height above floor (*feet*)	0.0 to −2.5	0.0–11.0	6.0–16.0
	(*percent*)	(*percent*)	(*percent*)
SiO_2		56.46	
Al_2O_3		16.1	
Fe_2O_3	5.90	7.48	7.30
CaO	7.60	3.31	3.59
MgO		3.72	
Na_2O		2.53	
K_2O		3.60	
TiO_2		0.87	
CO_2		0.14	
H_2O+		2.20	
H_2O-		3.18	
SO_3		0.54	
TOTAL		100.1	
Loss on ignition	6.38		3.93
Soluble salts	0.80		0.65

TABLE 123 Mineral Analyses:
Dochart Brick and Tile Company Limited
(A = abundant; B = moderate; C = minor;
D = trace; ND = not detected)

Sample	1	Little Bank 2	Big Bank 3
Height above floor (*feet*)	0.0 to −2.5	0.0–11.0	6.0–16.0
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	21	18	22
Calcite	6	ND	ND
Dolomite	3	ND	ND
Soda-lime feldspar	6	13	11
Potash feldspar	2	3	2
Amphibole	0.5–5	1–10	0.5–5
Gypsum		Trace	
Clay minerals			
Illite	A	A	A
Chlorite	D	C	D
Expanding minerals	B	B*	B*

*Montmorillonite

of 34-inch diameter, 16-inch smooth rolls, closely set. Tempering water is added to an F-R-H pug mill preceding the F-R-H combination pug and auger machine. Tile are extruded at more than 2,000 per hour, with de-airing at 12–16 inches vacuum, and are cut by a Fate automatic cutter.

A 27-track waste-heat tunnel dryer has a capacity of 80,000 tile. Drying time is 72 hours, and temperature at the hot end is 160° to 180°F. There are seven beehive kilns of 18- to 22-foot diameters with a total firing capacity of 124,000 tile. They are fired with natural gas to a peak temperature of 1780°F and are on-fire for 51 hours. Fired colour is orange-red.

TABLE 124 Ceramic Tests:
Dochart Brick and Tile Company Limited

SAMPLE 1: Main floor, 0.0′ to −2.5′

Water of plasticity (*percent*)	29
Lineal drying shrinkage (*percent*)	6.2
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2	0.2	7.0
Colour	light brown	light brown	red-brown
Hardness	soft	almost hard	very hard
24-hour absorption (%)	18.6	18.1	5.5
5-hour boil	19.5	19.3	9.2
Specific gravity	1.75	1.75	2.13

REMARKS: Briquettes are slightly overfired and marked by a fine yellow scum at cone 03.

SAMPLE 2: Little Bank, 0.0′–11.0′

Water of plasticity (*percent*)	30
Lineal drying shrinkage (*percent*)	5.7
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	2.0	9.7
Colour	brown	salmon	dark red
Hardness	soft	hard	very hard
24-hour absorption (%)	17.7	15.5	0.6
5-hour boil absorption (%)	18.1	16.4	0.9
Specific gravity	1.80	1.86	2.43

REMARKS: Briquettes are overfired at cone 03.

SAMPLE 3: Big Bank, 6.0′–16.0′

Water of plasticity (*percent*)	36
Lineal drying shrinkage (*percent*)	7.4
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.9	2.1	5.6
Colour	light salmon	salmon	dark red
Hardness	almost hard	hard	very hard
24-hour absorption (%)	18.7	16.7	0.1
5-hour boil absorption (%)	19.0	17.7	0.3
Specific gravity	1.77	1.83	2.09

REMARKS: Briquettes are overfired at cone 03.

ODM7461

Photo 38–Clay being hauled by gas locomotive at Dochart Brick and Tile Company Limited, 1961.

GEOLOGY

Stratified marine clay and silt, in places topped with sand, are found in considerable thickness in the valley of Dochart Creek. Mr. McKay reports that drilling has proved a thickness of 60 feet in the vicinity of his plant. The sequence was deposited on the bed of the Champlain Sea, an influx of marine water that entered the Hudson and Ottawa valleys in the van of the waning Wisconsinan ice. The sediments originated largely in the Precambrian rocks to the northeast, and entered the sea with meltwaters from the retreating ice-sheet.

The clay pit is worked in a single face 10–20 feet high and 500 feet long; the face is semi-circular in plan. The proportion of silt and sand interlayered with the clay varies over short distances. An 11-foot section known as the "Little Bank," at the northeast end of the face, contains sufficient sand to be used as it comes from the bank. A 16-foot bank at the west end of the face requires the addition of some sand; clay from this bank is stockpiled on the pit floor and mixed with sandy clay by bulldozer before being used in the plant. Clay containing lenses of sand in the main floor of the pit is sometimes excavated to a depth of 2–3 feet. Figure 33 illustrates a typical section through the Little Bank and main floor of the pit. Descriptions of the clay, and the results of chemical, mineralogical, and ceramic testing of vertical channel samples, are given in tables 122, 123, 124.

Sample (3) is a vertical channel sample of the upper 10 feet of the Big Bank section. It is a highly-plastic, almost massive, clay, in most respects similar to clay in the Little Bank section. The top 1.5 feet is sandy loam in both sections.

Photo 39—Dresden Tile Yard Limited; plant 1960.

DRESDEN TILE YARD LIMITED

A plant one mile north of Dresden has been owned by D. J. McCaughrin since 1946. First production from this site was in 1907. The existing plant was partly re-built following a fire in 1960. It is located in lot 8, concession V, Gore of Camden township, Kent county. An early description of the plant is given by Montgomery (1930, p. 130).

Plant

Twenty men are employed for a season of 9 or 10 months, during which 4 million tile in all sizes from 4 to 12 inches are produced.

Clay from the pit is dug by a ½-yard Bay City dragline and trucked about 1,000 feet to the plant. A 1-to-5 addition of a highly plastic "gumbo" clay is facilitated by dumping the latter on top of the bank in the main pit and reclaiming both clays together. In 1965 a mixing and grinding plant employing a Handle proportioning box feeder was being constructed to replace the earlier mixing method. A storage shed constructed of concrete block with asbestos sheet roofing is approximately 120 by 56 by 14 feet. It provides ample clay storage for late fall and early spring production. A 1½-yard Caterpillar Traxcavator delivers clay from the stockpile to a double shaft pug feeder. This is followed by a 20-inch Parkhill rolls disintegrator and a 36-inch diameter 18-inch, Steele smooth rolls crusher. The clay is delivered by belt conveyor to a Steele 30E single-shaft auger machine which produces tile at the rate of 1,800 per hour. Water is added in the pugging section and de-airing is accomplished under a vacuum of 15 inches. The single clay stream is cut by a Fate cutter. Tile are hacked in three tiers, 200 per rack, and are moved to the dryers by forklift truck.

Two waste-heat room dryers, 115 by 36 feet, hold 28,000 tile each. The section above one of the rooms is used for drying large tile. Drying time in the rooms is 2 days at 125°F. There are four beehive kilns of 24- to 28-foot diameters having a total capacity of 100,000 tile. They are protected from the weather by a steel-framed shed roof. The kilns are gas-fired to a peak temperature of 1800°F and are turned over on a 6-day cycle.

The red-fired tile are shipped by truck from yard storage. Tile are palletized in blocks of 364 for some shipments.

GEOLOGY

Much of the surface of Essex, Kent, and Lambton counties has been smoothed and levelled by the re-working of the till that formed the bed of glacial Lakes Whittlesey and Warren. Thin deposits of stratified silt and clay were formed in the depressions, while the knolls of till were being lowered by wave and current action. The flat country east of Lake St. Clair remained submerged during a high level stage of the lake, following the general retreat of Lake Warren, and some stoneless clay was also deposited at this stage.

Two pits are worked by Dresden Tile Yard Limited. Both are shallow deposits located just

TABLE 125 Main Pit Section: Dresden Tile Yard Limited

Height above floor (*feet*)	Description	Thickness (*feet*)
6.0–7.0	TOPSOIL: Grey-brown to black, crumbly, clay-loam.	1.0
3.5–6.0	CLAY: Grey-brown silty clay; uniform, massive, tough, blocky; occasional fine roots.	2.5
0.0–3.5	CLAY AND SILT: Brown clay and yellow silt; uniformly stratified in layers $\frac{1}{4}$–$\frac{1}{2}$ inches thick; rusty streaks and root channels.	3.5
0.0	PIT FLOOR: Medium-grained rust-brown sand is sometimes present in thick lenses.	

TABLE 126 Partial Chemical Analyses: Dresden Tile Yard Limited

Sample	Main Pit 1	Dawn tp. pit 2
Height above floor (*feet*)	0.0–7.0	0.0–4.0
	(*percent*)	(*percent*)
Fe_2O_3	5.65	6.18
CaO	3.57	5.16
Loss on ignition	8.48	12.83
Soluble salts	0.73	0.87

TABLE 127 Mineral Analyses: Dresden Tile Yard Limited (A = abundant; B = moderate; C = minor; ND = not detected)

Sample	Main Pit 1	Dawn tp. pit 2
Height above floor (*feet*)	0.0–7.0	0.0–4.0
	(*percent*	(*percent*)
Non-clay minerals		
Quartz	31	21
Calcite	2	5
Dolomite	1	1
Soda-lime feldspar	2	<0.5
Potash feldspar	2	ND
Amphibole	ND	<1
Clay minerals		
Illite	A	A
Chlorite	B	C
Expanding minerals	C	C

TABLE 128 Ceramic Tests: Dresden Tile Yard Limited

SAMPLE 1: Main pit, 0.0′–7.0′

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	5.8
Pyrometric cone equivalent	4

	Cones 010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4	2.3	6.9
Colour	salmon	dark salmon	red-brown
Hardness	very hard	very hard	very hard
24-hour absorption (%)	12.8	8.5	1.1
5-hour boil absorption (%)	13.5	10.2	1.3
Specific gravity	1.91	2.01	2.32

REMARKS: Briquettes are well-burned at cone 010, but are still not deformed at cone 03.

SAMPLE 2: Dawn tp. pit, 0.0′–4.0′

Water of plasticity (*percent*)	32
Lineal drying shrinkage (*percent*)	7.7
Pyrometric cone equivalent	5–6

	Cones 010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2	2.2	8.8
Colour	salmon	salmon	red-brown
Hardness	very hard	very hard	very hard
24-hour absorption (%)	15.2	12.4	1.5
5-hour boil absorption (%)	15.8	13.3	1.8
Specific gravity	1.75	1.81	2.20

REMARKS: Briquettes are well-burned at cone 010; they exhibit slight yellow scum at cone 06; they are overfired and slightly deformed at cone 03.

within the former shoreline of early Lake St. Clair. The main pit is just south of the plant in lot 8, concession V, Gore of Camden township. It is an opening 500 feet by 300 feet, 6-7 feet deep, adjoining earlier more extensive workings. A 7-foot section is described in Table 125.

A second pit is located in the southwest corner of lot 11, concession IV, Dawn township, about two miles northwest of the plant. It is used in limited amounts to improve the plasticity of the plant feed. Clay has been excavated to a depth of 6–7 feet over a small area. The clay is a medium green-grey colour mottled with brown and rusty markings. It is massive, highly plastic, and tough, and exhibits a white efflorescence on dry surfaces. Sub-rounded pebbles up to several inches in size are present in low amount; grey-black shale, brown limestone, and granite fragments are most common. Black carbonaceous material and a few white shells are found locally.

Chemical, mineralogical, and ceramic test results are given in tables 126, 127, 128. Sample (1) is a 7-foot vertical channel sample from the main pit; sample (2) is a 4-foot vertical channel sample from the pit in Dawn township.

ELLIOTT'S BRICK AND TILE YARD

The late W. J. Elliott was the owner of a plant 6 miles northeast of Wingham. It has been owned by the Elliott family since 1883; and much of the equipment was designed by Mr. Elliott's father. It is located just within the southern boundary of Bruce county, in lot 8, concession I, Culross township. Early descriptions of the clay and plant are given by Baker (1906, p. 71) and Montgomery (1930, pp. 109–110). The plant was closed in 1962.

Plant

The plant was operated for a 6-month season, and 6 or 7 men were employed. One-quarter million drain tile in sizes from 3 to 8 inches, and occasionally to 16 inches, were produced. An average of 50,000 standard-sized brick were also produced yearly. The clay burns to an unusual cream-white colour.

Clay was taken from the bank by a small Wagner backhoe mounted on an International No. 300 rubber-tired tractor. At the plant all equipment was belt-driven from a gasoline-powered tractor. The clay was fed to a wood-stave pug mill with a single shaft. A Baird extruder was operated at the rate of 850 tile per hour. Tile were cut by a Brewer hand cut-off; brick were cut by a machine of Mr. Elliott's own design.

Adequate drying capacity was provided by open-air sheds. A two-chamber rectangular downdraft kiln has 8 fireboxes on each side and 18 stacks along the centre partition. Each chamber measures 40 by 12 by 12 feet inside and holds 22,000 tile. For burning, small tile were stacked in the bottom rows with progressively larger tile towards the top. Seven rows of brick were usually fired at the top of the kiln. Wood was burned during the 48-hour "water-smoking" period; then wood and coal. A soaking period of 48 hours was maintained at the peak temperature of 1850°–1900°F at the top, and 1600°F at the bottom. The chambers were operated in rotation, each chamber being fired separately. Production averaged 10 or 12 chamber-loads per season.

GEOLOGY

The area between Wingham and Walkerton is referred to physiographically as the "Teeswater drumlin field" (Chapman and Putnam 1951, pp. 163–165); during late Wisconsinan time it was traversed by rivers of meltwater from the ice-fronts along the northwest edge of the highland region known as "Ontario Island." Shallow irregular deposits of stoneless clay have, in some places, been formed by the re-working of a brown limy till, derived largely from the bedrock limestones of the Bois Blanc Formation and the Detroit River Group. In most cases the clays are unstratified, representing a sifting and re-sorting of the upper few feet of till, rather than redeposition.

Small, shallow, excavations are scattered on both sides of the road that marks the county line. In general, the top 2–3 feet burns to a pink colour, while that below burns almost white. Little of the top clay now remains, but a 2½-foot sample (sample (2)) was obtained on the south side of the road, just behind the farmhouse, in lot 8, concession XII, Turnberry township, Huron county. It is a smooth, plastic, orange-brown clay mottled with blue-grey markings that trace former root systems. It dries to a cream-white colour, except in the top foot which grades into a dark loamy topsoil.

In the same lot, 500 feet south of the road, 2½ feet of the lower grey clay is exposed, beneath 1½ feet of brown clay and loam similar to that previously sampled. The lower clay is a pale olive-grey, smooth, plastic, massive clay mottled with rusty markings. It dries to a pale cream colour, and it contains a few small subangular pebbles of white limestone. Sample (1) is a 2½-foot vertical channel sample of the lower grey clay.

The results of chemical, mineralogical, and ceramic testing of the two samples are given in tables 129, 130, 131.

TABLE 129 Chemical Analyses: Elliott's Brick and Tile Yard

Sample	1	2	Composite
Height above floor (*feet*)	0.0–2.5	2.5–5.0	0.0–5.0
	(*percent*)	(*percent*)	(*percent*)
SiO_2			40.21
Al_2O			8.06
Fe_2O_3	3.12	3.65	3.25
CaO	20.8	13.1	17.2
MgO			7.08
Na_2O			0.87
K_2O			2.51
TiO_2			0.50
CO_2			17.22
H_2O+			1.82
H_2O-			1.19
SO_3			0.17
TOTAL			100.1
Loss on ignition	23.05	18.61	21.51
Soluble salts	0.88	0.88	

TABLE 130 Mineral Analyses: Elliott's Brick and Tile Yard (B = moderate; C = minor; ND = not detected)

Sample	1	2	Composite
Height above floor (*feet*)	0.0–2.5	2.5–5.0	0.0–5.0
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	21	23	24
Calcite	12	5	11
Dolomite	26	16	22
Soda-lime feldspar	3	3	2
Potash feldspar	<0.5	2	<0.5
Amphibole	<1	ND	<1
Clay minerals			
Illite	B	B	B
Chlorite	C	B	C
Expanding minerals	B	B	B*

*Montmorillonite

TABLE 131 Ceramic Tests: Elliott's Brick and Tile Yard

SAMPLE 1: 0.0′–2.5′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.6
Pyrometric cone equivalent	6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0	0.8	1.9
Colour	pale salmon	pink-cream	cream-white
Hardness	soft	moderately soft	almost hard
24-hour absorption (%)	27.2	27.5	27.8
5-hour boil absorption (%)	27.2	31.2	32.6
Specific gravity	1.49	1.43	1.41

SAMPLE 2: 2.5′–5.0′

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	5.5
Pyrometric cone equivalent	6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	0.2
Colour	salmon	cream-pink	cream-buff
Hardness	soft	moderately hard	hard
24-hour absorption (%)	22.9	22.6	20.6
5-hour boil absorption (%)	25.2	26.4	26.8
Specific gravity	1.56	1.55	1.57

ELLIOTT'S BRICKYARD

J. T. and S. A. Elliott are co-owners of a brick plant in the northwestern outskirts of Sault Ste. Marie. Their father, James Elliott, built the plant in 1901. It is located in section 25, Korah township, District of Algoma. Early descriptions of the plant are given by Baker (1906, pp. 57–58) and Montgomery (1930, p. 107); Keele (1924, p. 123) describes the clay.

Plant

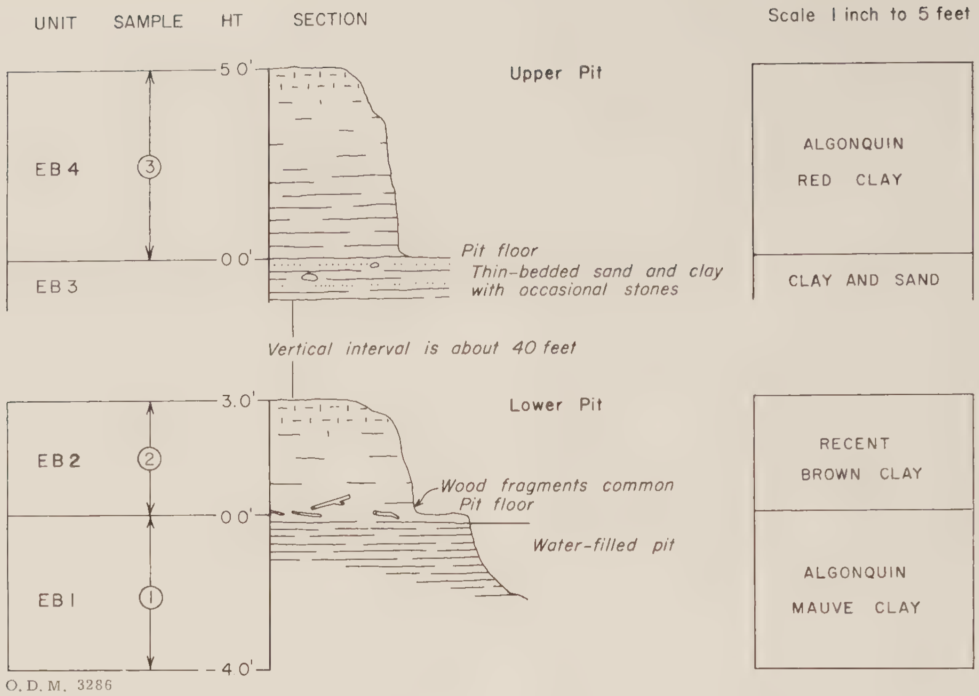
Some 800,000 standard-sized brick and 75,000 drain tile are produced in the 6-month working season. Twelve men are employed.

A red and a brown clay are mixed in equal proportions and a small amount of sand is added. The clays are taken from the bank by a John Deere ½-yard front-end loader and a Quick-way backhoe mounted on a 4-wheel-drive army truck. Two 3½-ton GMC dump trucks haul the clay 800 feet to the plant and dump directly to a feed hopper or ramp. A 15-inch chain and bucket-type conveyor picks up clay from the hopper or is hand-loaded from the ramp. It feeds a set of 16-inch Steele disintegrator rolls that discharge to a 12-foot double-shaft Baird pug mill. A Baird extruder is fed by a 15-inch belt, and a Brewer 8-brick cutter is hand-operated. The equipment is capable of producing as much as 2,500 brick per hour. The brick are hacked on wooden pallets and are taken to the drying racks by wheelbarrow. Tile are hacked in three tiers, 72 to a platform, and are taken to the drying areas by Clark forklift truck. Brick are finished with either a smooth or brush texture. There is no de-airing.

There are 22 rows of open-air drying racks, 140 feet long, with a capacity of 165,000 brick. Two rectangular kilns have each been divided in half, making four firing chambers with a total capacity of 165,000 brick. They are wood-fired to a peak temperature of 1950°F and are operated on a 15-day cycle. Hardwood slabs are available in quantity at a large lumber mill adjoining the plant. Brick are produced in red or flashed colours and are kept in covered storage and shipped by truck.

GEOLOGY

A prominent terrace traces a sinuous course across Sault Ste. Marie, dividing older sections of the city from new residential developments on the north and


UNIT
SAMPLE
HT
SECTION
Scale 1 inch to 5 feet
5.0'
Upper Pit
EB 4
③
ALGONQUIN
RED CLAY
0.0'
Pit floor
Thin-bedded sand and clay with occasional stones
EB 3
CLAY AND SAND
Vertical interval is about 40 feet
3.0'
Lower Pit
EB 2
②
RECENT
BROWN CLAY
Wood fragments common
Pit floor
0.0'
Water-filled pit
EB 1
①
ALGONQUIN
MAUVE CLAY
-4.0'
O.D.M. 3286

Unit		Thickness (*feet*)
EB 4	CLAY: Medium red-brown, drying pale brown; uniform, dense, smooth, stoneless; stratified in layers ¼–3-inches thick becoming less distinct due to weathering at top.	5.0
EB 3	CLAY AND SAND: Brown clay and yellow sand; stratified in layers ⅛–¼ inches thick; occasional pebbles; approximately equal proportions of clay and sand.	2+
EB 2	CLAY: Olive-green, grading upwards through orange-brown to grey-black; massive, plastic, stoneless; loamy at top; wood fragments abundant at base.	3.0
EB 1	CLAY: Mauve-brown, drying pink; smooth, plastic, uniform; stratified (varved?) in layers ⅛–¼ inches thick; friable and chalky when dry.	4+

Figure 34–Elliott's Brickyard, pit sections.

east sides. The terrace marks the shoreline of an early, high-level, stage of Lake Superior; it is cut into the red-brown stratified clays that were deposited by ancestral Lake Algonquin during the final recession of the glaciers in late Wisconsinan time. A few feet of massive brown clay containing numerous wood fragments were deposited below the terrace on the early Lake Superior flood plain. Stratified Lake Algonquin clays also underlie these Recent sediments.

At the brickyard the plant buildings are located at the foot of the terrace, which here is rather abrupt and 50 feet high. Clay is obtained from two pits, one in Lake Algonquin clay at the top of the terrace, and one 800 feet to the west in Recent clay on the flood plain. Figure 34 is a composite section through the two pits; the clays are described in accompanying notes. Chemical, mineralogical, and ceramic data are given in tables 132, 133, 134.

TABLE 132 Chemical Analyses: Elliott's Brickyard

Sample	1 Mauve clay	2 Brown clay	3 Red clay	Composite: 2 and 3 Red and Brown clays
Height above floor (*feet*)	bulk	0.0–3.0	0.0–5.0	
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				60.13
Al_2O_3				16.1
Fe_2O_3	3.43	5.10	6.33	5.93
CaO	5.30	2.93	5.22	3.21
MgO				2.39
Na_2O				1.83
K_2O				3.41
TiO_2				0.69
CO_2				1.92
H_2O+				2.67
H_2O-				2.03
SO_3				0.45
TOTAL				100.8
Loss on ignition	4.94	6.28	9.66	7.72
Soluble salts	0.88	0.56	0.86	

TABLE 133 Mineral Analyses: Elliott's Brickyard
B = moderate; C = minor; ND = not detected)

Sample	1 Mauve clay	2 Brown clay	3 Red clay	Composite: 2 and 3 Red and Brown clay
Height above floor (*feet*)	bulk	0.0–3.0	0.0–5.0	
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	39	33	21	24
Calcite	3	ND	4	2
Dolomite	3	ND	2	1
Soda-lime feldspar	6	17	5	9
Potash feldspar	1	2	<0.5	2
Amphibole	0.5–5	0.5–5	<1	<1
Clay minerals				
Illite	B	B	B	B
Chlorite	B	B	B	B
Expanding minerals	C	B	B	B*

*Montmorillonite

TABLE 134 Ceramic Tests: Elliott's Brickyard

SAMPLE 1: Mauve clay, bulk

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	3.5
Pyrometric cone equivalent	3

	Cones 010 (1660°F)	06 (1840°F)	03 (1990°F)
Lineal firing shrinkage (%)	0.3 expansion	0.2	7.4
Colour	dark tan	tan-pink	dark pink-brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)	21.0	19.7	4.3
5-hour boil absorption (%)	22.7	21.8	5.1
Specific gravity	1.64	1.66	2.20

REMARKS: Briquettes are overfired, slightly deformed, and marked by yellow scum at cone 03.

SAMPLE 2: Brown clay, 0.0′–3.0′

Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	7.1
Pyrometric cone equivalent	4

	Cones 010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4	2.3	5.2
Colour	salmon	dark salmon	red-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	15.3	10.6	0.5
5-hour boil absorption (%)	16.5	12.9	0.8
Specific gravity	1.80	1.91	2.37

REMARKS: Briquettes are overfired but not deformed at cone 03.

SAMPLE 3: Red clay, 0.0′–5.0′

Water of plasticity (*percent*)	35
Lineal drying shrinkage (*percent*)	9.0
Pyrometric cone equivalent	3–4

	Cones 010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	1.5	8.5
Colour	salmon	dark salmon	red-brown
Hardness	hard	very hard	very hard
24-hour absorption (%)	18.1	15.1	0.7
5-hour boil absorption (%)	19.3	16.3	1.0
Specific gravity	1.78	1.84	2.40

REMARKS: Briquettes are overfired at cone 03.

EMIG CLAY PRODUCTS LIMITED

One of the largest plants in southwestern Ontario is located on the eastern outskirts of Chatham in lot 3, concession 1, Harwich township, Kent county. J. B. Emig purchased the plant from James Cornhill and Sons Limited. The Cornhill family built this plant in 1929, but had operated a previous plant in Chatham since 1865. An early description of the present plant is given by Montgomery (1930, p. 129).

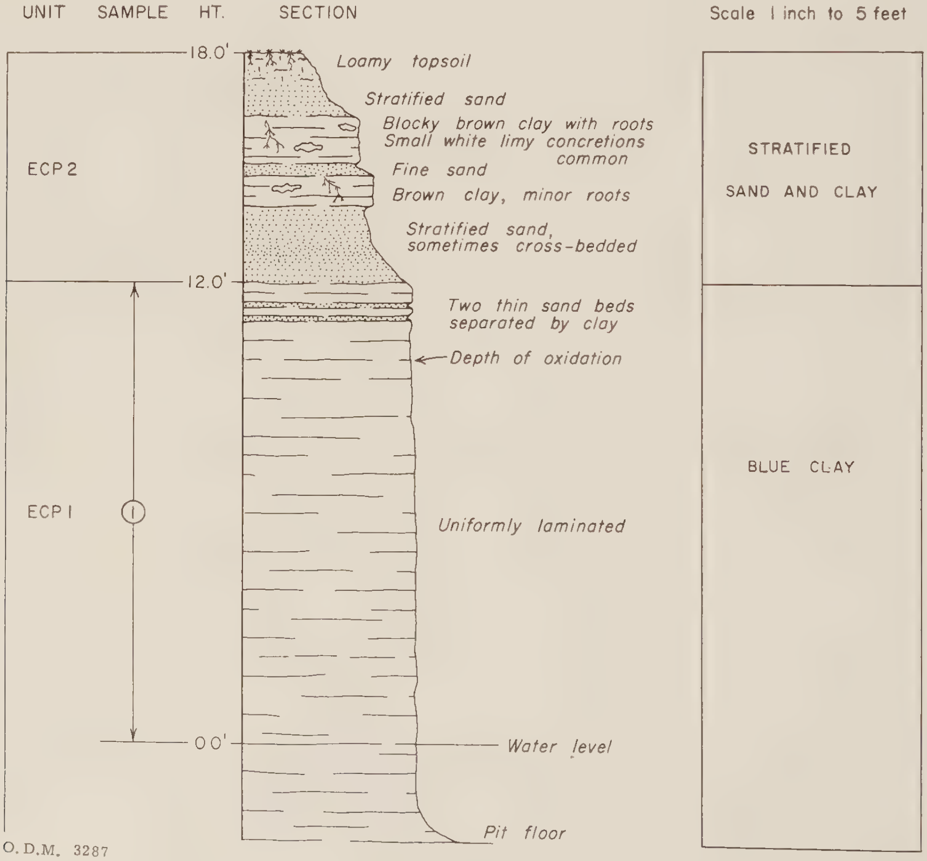
Plant

The operation employs 35 men for the full year. Drain and structural tile, Roman and Standard brick, and flue liners are the main products. They are produced according to the local demand, which was predominantly for brick in 1960 but drain tile in 1961. Between 13,000 and 14,000 tons of fired products are made in an average year.

TABLE 135 Emig, Raleigh Twp. Pit

Height above pit floor (*feet*)	Description	Thickness (*feet*)
1.8–2.5	TOPSOIL: Grey-black to black, tough, silty clay topsoil.	0.7
0.8–1.8	CLAY: Olive-grey, mottled with rusty and black markings; smooth, massive, plastic; fine roots and occasional shells.	1.0
0.0–0.8	SILT: Grey-brown, mottled with rusty and black markings; massive clayey silt.	0.8

Buff-burning "blue clay" is taken from the bank by a 1-yard Insley dragline, and is hauled by truck about 800 feet to an open-air stockpile at the plant. A separate stockpile is maintained for a red-burning "surface clay" trucked from a shallow pit six miles west of the city. The two clays are batched by a Hough Payloader, the proportion of surface clay


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
18.0'
12.0'
0.0'
ECP 2
ECP 1
1
Loamy topsoil
Stratified sand
Blocky brown clay with roots
Small white limy concretions common
Fine sand
Brown clay, minor roots
Stratified sand, sometimes cross-bedded
Two thin sand beds separated by clay
Depth of oxidation
Uniformly laminated
Water level
Pit floor
STRATIFIED SAND AND CLAY
BLUE CLAY
O.D.M. 3287

Unit		Thickness (*feet*)
ECP 2	SAND AND CLAY: Fine-grained, stratified, yellow sand, interbedded with tough, brown, blocky, faintly laminated clay; small white limy concretions are common in the clay sections.	6.0
ECP 1	CLAY: Blue-grey clay interlayered with minor pale grey silt; clay is plastic, dense, stoneless; stratified in layers 1–3 inches thick, with a finer (¼–½ inches) and less distinct lamination superimposed; stratification is marked by ¼-inch silt layers; lamination is marked by a thin sprinkling of silt; top 2 feet is oxidized to brown.	12+

Figure 35–Emig Clay Products Ltd., Chatham pit section.

TABLE 136 Chemical Analyses: Emig Clay Products Limited

Sample	Main pit, Harwich tp. 1	Raleigh tp. pit 2
Height above floor (*feet*)	0.0–12.0	0.0–2.5
	(*percent*)	(*percent*)
SiO_2	45.59	
Al_2O_3	8.60	
Fe_2O_3	3.80	3.85
CaO	14.7	2.82
MgO	4.98	
Na_2O	1.01	
K_2O	2.42	
TiO_2	0.57	
CO_2	14.83	
H_2O+	1.89	
H_2O-	0.47	
SO_3	0.49	
TOTAL	99.4	
Loss on ignition	17.25	8.47
Soluble salts		0.49

TABLE 137 Mineral Analyses: Emig Clay Products Limited
(A = abundant; B = moderate; C = minor;
D = trace; ND = not detected)

Sample	1	2
Height above floor (*feet*)	0.0–12.0	0.0–2.5
	(*percent*)	(*percent*)
Non-clay minerals		
Quartz	32	34
Calcite	13	<0.5
Dolomite	20	4
Soda-lime feldspar	4	4
Potash feldspar	2	2
Amphibole	<1	ND
Clay minerals		
Illite	B	A
Chlorite	C	C
Expanding minerals	D	B

TABLE 138 Ceramic Tests: Emig Clay Products Limited

SAMPLE 1: Main pit, 0.0′–12.0′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	4.1
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.5	1.0	0.7
Colour	tan	cream-grey	buff
Hardness	almost hard	almost hard	hard
24-hour absorption (%)	22.6	19.6	19.7
5-hour boil absorption (%)	24.8	26.3	27.7
Specific gravity	1.60	1.56	1.56

SAMPLE 2: Raleigh tp. pit, 0.0′–2.5′

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	6.7
Pyrometric cone equivalent	6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4	2.0	6.1
Colour	salmon	dark salmon	red-brown
Hardness	very hard	very hard	very hard
24-hour absorption (%)	13.6	10.0	2.3
5-hour boil absorption (%)	15.3	13.4	4.6
Specific gravity	1.85	1.91	2.23

REMARKS: Briquettes are slightly overfired at cone 03.

depending on the depth of red colour desired in the fired brick. Tile are made predominantly from the red-burning surface clay. An F-R-H 4-shaft pug feeder feeds clay to a set of 18-inch M.E.C. disintegrator rolls. A 24-inch belt conveyor discharges to a set of F-R-H 24-inch by 24-inch closely-set smooth rolls. A double-shaft, de-airing, F-R-H extruder can produce in excess of 60,000 Roman brick or 26,000 drain tile during an 8-hour day. Tile of 4-inch diameter are extruded in a double stream, but all larger sizes are single. De-airing is accomplished at 16 inches of vacuum for tile, and 24 inches for brick. A Fate cutter is used for tile and a Frey Universal for brick. The ware is hacked 150 tile, or 300 brick, to a car.

Drying is carried out in a 10-track waste-heat tunnel dryer or a 30-track room dryer, each track having a capacity of 18 cars. Drying time is 3 to 5 days. There are 10 coal-fired beehive kilns with diameters of 24–32 feet capable of handling an average of 60 tons of ware each. The kilns are on-fire for about 100 hours and reach a peak temperature of 1800°F.

Shipments are made from yard storage by truck or rail.

GEOLOGY

Glacial lakes Whittlesey and Warren failed to leave deposits of stratified clay on the underlying till except in a few restricted areas (Chapman and Putnam, p. 176). One such area occurs in the vicinity of Chatham. In the low flat country on the south side of the Thames River on the eastern edge of town 14 feet of blue-grey stratified clay are exposed in the pit of Emig Clay Products Limited. The section is illustrated in figure 35 and described in the accompanying notes.

A 6-foot section of stratified clay, silt, and fine sand overlies the blue-grey clay. These are Recent deposits laid down on the Thames River flood plain. Formerly mixed with the underlying buff-burning clay for brick and tile manufacture, these surface materials are now largely removed, and a shallow pit has been opened west of the city instead.

Red-burning clay is obtained north of Highway No. 2, in lot 12, concession IV, Raleigh township, 6 miles west of the plant. The clay is typical of the stonefree top of the brown till that underlies much of Essex, Kent, and Lambton counties. The 2½-foot section is described in Table 135. Sample (1) is a 12-foot vertical channel sample of the buff-burning blue-grey clay from the main clay pit at the plant; sample (2) is a 2½-foot vertical channel sample of the red-burning clay from the pit in Raleigh township. The results of chemical, mineralogical, and ceramic testing are given in tables 136, 137, 138.

FLETCHER TILE LIMITED

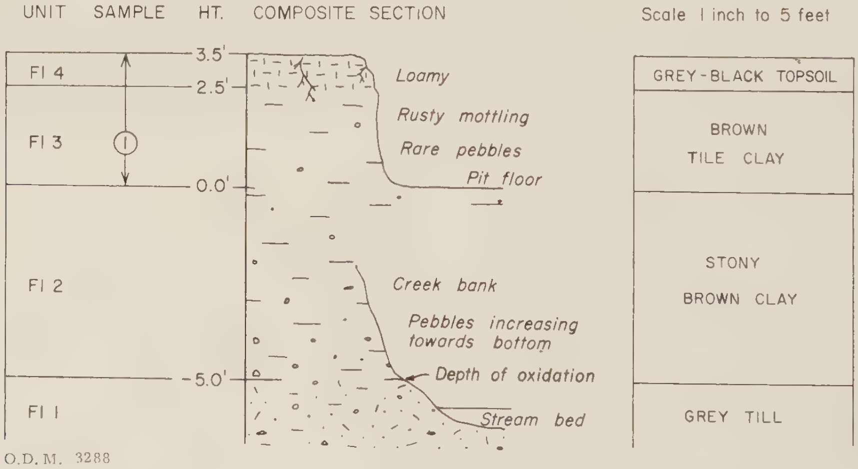
This plant was built in 1912 by T. H. Armstrong and his brother. It was worked by the Denison Tile Company from 1925 to 1929, and was subsequently owned by Fred Halett and Sons, before reverting again to the Armstrongs. It was purchased by R. C. Cook in 1964. An early description of the plant is given by Montgomery (1930, p. 129). The plant is located at Fletcher, in lot 1, concession VIII, Tilbury East township, Kent county.

Plant

The operation is continuous throughout the year and 18 men are employed. Some 2½ million tile are produced annually in all sizes from 4 inches. Some are made with two double rows of perforations for increased drainage in heavy clay soils.

Clay is dug from the bank with a ½-yard Lorain shovel and is hauled by truck to a large open-air stockpile at the plant. It is reclaimed by front-end loader dumping into a Brewer 4-shaft pug feeder. A 15-inch belt feeds a set of smooth conical rolls tapering from 18 to 14 inches in diameter and turning at a 3-to-1 speed differential. A 93-horsepower Minneapolis Moline motor burning natural gas is the drive for the Plymouth Special, de-airing, double-shaft auger machine. Tile are extruded in a single stream for all sizes larger than 4-inch; 4-inch tile are extruded in a double stream. De-airing is accomplished by a vacuum of 8 to 15 inches, and the clay stream is cut by an F-R-H cutter. The tile are hacked in two tiers, 156 per car.

A 25-track manual-push tunnel dryer uses waste heat to maintain a temperature of 250°F at the hot end. Natural gas provides auxiliary heat as required. Drying capacity is 50,000 tile and drying time is 3 days. Additional drying capacity is available above the tunnels, and in the summer months large tile are dried outside. Ther are five beehive kilns, three of 25-foot and two of 27-foot inside diameters. The smaller kilns hold 18,500 tile, the larger 22,000.



Unit		Thickness (*feet*)
FL 4	TOPSOIL: Grey-black; loamy; stoneless; with a few fine roots.	1.0
FL 3	CLAY: Grey-brown; tough, plastic; massive; rare pebbles and fine roots; mottled with rusty streaks.	2.5
FL 2	CLAY: Grey-brown; tough, plastic; massive; pebbles increasing with depth.	5.0
FL 1	TILL: Blue-grey; dense, plastic, gritty; massive; pebbles common.	2+

Figure 36–Fletcher Tile Ltd., pit section.

ODM7463

Photo 40—Fletcher Tile Limited; plant 1965.

They are gas-fired to a peak temperature of 1700–1800°F, and each kiln is worked on an 8-day cycle.

The tile burns to a bright orange-red colour. Shipments are made by truck from yard storage.

GEOLOGY

Clay is obtained ½ mile west of the plant in lot 2, concession VIII, Tilbury East township, Kent county. Excavation to a depth of 3½ feet has been carried out over a large area. Light vegetation is controlled by periodic raking and harrowing. Occasional rounded pebbles are found in the massive brown clay, and they become more numerous below the pit floor. In a creek bank several hundred feet south of the pit the brown clay can be seen to extend to a depth of 8 feet. Pebble content increases with depth but is not excessive, and consideration has been given to the addition of two more rolls crushers so that clay could be taken to a greater depth. Below the oxidized zone is the typical blue-grey till. Pebbles of all sizes are fairly common in the till; dark grey shale pebbles predominate but limestone and Precambrian pebbles are also present.

A composite section through the pit and creek bank is illustrated in figure 36 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of a 3½-foot vertical channel sample from the pit face are given in tables 139, 140, 141.

TABLE 139 Partial Chemical Analysis: Fletcher Tile Limited

Sample	1
Height above floor (*feet*)	0.0–3.5
	(*percent*)
Fe_2O_3	4.59
CaO	1.42
Loss on ignition	7.88
Soluble salts	0.57

TABLE 140 Mineral Analysis: Fletcher Tile Limited
(A = abundant; C = minor; ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–3.5
	(*percent*)
Non-clay minerals	
Quartz	44
Calcite	ND
Dolomite	ND
Soda-lime feldspar	3
Potash feldspar	1
Amphibole	ND
Clay minerals	
Illite	A
Chlorite	C
Expanding minerals	C

TABLE 141 Ceramic Tests: Fletcher Tile Limited

SAMPLE 1: 0.0′–3.5′

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	5.7
Pyrometric cone equivalent	10

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4	3.2	7.1
Colour	salmon	salmon-red	red-brown
Hardness	hard	very hard	very hard
24-hour absorption (%)	12.6	7.7	0.6
5-hour boil absorption (%)	13.6	9.2	1.1
Specific gravity	1.90	2.08	2.37

REMARKS: Briquettes are blistered and overfired at cone 03.

GOMOLL BRICK AND TILE

A small tile yard is operated at Powassan, in lot 15, concession XI, Himsworth township, district of Parry Sound. An early description of the plant is given by Baker (1906, p. 88).

Plant

The plant output is about 300,000 drain tile in the 6-month working season. Brick are occasionally produced.

The sandy clay-loam topsoil and the underlying varved clays are mixed in equal proportions and stored in a small covered stockpile at the plant. Clay is reclaimed from storage by a John Deere No. 40 tractor equipped with a 1-yard front end bucket. The clay is fed via hopper and belt to a 20-inch Parkhill double-roll disintegrator. An 11-inch belt feeds the F-R-H Plymouth Special de-airing extruder. Tile are extruded in a single stream and cut by a Frey Universal cutter. They are hacked on triple-tier steel racks, 230 per rack, and are transported to open-air drying sheds by forklift truck.

There is one beehive kiln about 25 feet in diameter. Slab wood is used for fuel, and the tile burn to a medium orange-red colour.

TABLE 142 Chemical Analyses: Gomoll Brick and Tile

Sample	Varved clay 1	Sandy loam 2	Clay and sand (Baker 1906, p. 26)
Height above floor (*feet*)	bulk	bulk	0.0–12.0
	(*percent*)	(*percent*)	(*percent*)
SiO_2			65.42
Al_2O_3			16.06
Fe_2O_3	4.95	4.82	5.44
CaO	2.96	2.87	3.20
MgO			2.31
Na_2O			1.90
K_2O			3.06
SO_3			0.07
Loss on ignition	2.30	2.28	2.78
Soluble salts	0.56	0.41	

TABLE 143 Mineral Analyses: Gomall Brick and Tile
A = abundant; B = moderate; C = minor;
ND = not detected)

Sample	Varved clay 1	Sandy loam 2
Height above floor (*feet*)	bulk	bulk
	(*percent*)	(*percent*)
Non-clay minerals		
Quartz	23	29
Calcite	ND	ND
Dolomite	ND	ND
Soda-lime feldspar	8	12
Potash feldspar	<0.5	2
Amphibole	1–10	1–10
Clay minerals		
Illite	A	A
Chlorite	B	C
Expanding minerals	B	B

TABLE 144 Ceramic Tests: Gomoll Brick and Tile

SAMPLE 1: Varved clay

Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	4.0
Pyrometric cone equivalent	1

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	1.5	8.9
Colour	pale salmon	salmon	red-brown
Hardness	moderately hard	hard	very hard
24-hour absorption (%)	15.3	13.7	1.4
5-hour boil absorption (%)	16.2	14.6	1.6
Specific gravity	1.83	1.90	2.39

REMARKS: Briquettes are overfired at cone 03.

SAMPLE 2: sandy loam

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	3.6
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3	4.0
Colour	pale salmon	salmon	red
Hardness	moderately hard	almost hard	very hard
24-hour absorption (%)	15.4	14.8	7.9
5-hour boil absorption (%)	17.2	17.0	10.5
Specific gravity	1.78	1.81	2.02

REMARKS: Briquettes are slightly overfired at cone 03.

GEOLOGY

Varved clay deposited on the floor of glacial Lake Algonquin is found in thick deposits in several of the major river valleys in the Parry Sound and Muskoka districts. Clay at Powassan, in the valley of the South River, has been used for brick and tile for many years. The deposit is described by Satterly (1943, pp. 17–18) as follows:

> Varved clay is well exposed in the pit of the Gomoll Brick and Tile Works just south of Powassan in South Himsworth township. The section exposed in the pit from top to bottom is: 2 feet of coarsely varved, silty clay; 1½ feet of reddish varved clay; and 3 feet of coarsely varved clay, in which 40 varves occur in 34 inches, 10 of these varves being in the lower 12 inches. The manager reports that below the floor of the pit drilling shows another 12 feet of clay, after which quicksand is reached. The total thickness of clay on the property is approximately 20 feet. Assuming that the rate for deposition was the same as in the lower 12 inches of the pit, that is 1 foot in 10 years, then it is apparent that a glacial lake existed in this locality for 200 years or more.

In 1961, clay was being removed by scraper from a shallow irregular pit several hundred yards south of the plant. The surface 1–2 feet consists of olive-grey sandy loam containing rare pebbles. Below this, the clay is distinctly varved in layers ⅛–¼ inches thick, consisting of smooth, plastic, medium-brown clay and olive-grey silt. The results of chemical, mineralogical, and ceramic testing of bulk samples of the surface loam and varved clay are given in tables 142, 143, 144.

GRAVELL BRICK COMPANY LIMITED

Operated for many years by R. Wallace and Son, a brick plant 2 miles east of North Bay was re-opened in 1961 by Andre Gravell of Hamilton. The plant is located near the west end of Trout Lake, in lot 16, concession C, Widdifield township, Nipissing District. The plant was extensively renovated by Mr. Gravell, and was operated continuously until March 1965 when it was closed. Early descriptions of brick-making on this site are given by Baker (1906, p. 83), Keele (1924, p. 120), and Montgomery (1930, p. 140).

Plant

The plant was operated the year round and employed 30 people. Production was 6 million standard-sized brick per year.

Clay was taken from the pit by front-end loader and trucked to a large open stockpile at the plant. A small covered stockpile was also maintained for use during wet weather. Clay was reclaimed from stock by front-end loader and delivered by pug feeder to a set of smooth rolls. After further pugging the clay was delivered to an F-R-H Junior combined pug and auger extruder. De-airing was accomplished at 25 inches of vacuum, and the brick stream was cut by a Frey Universal cutter. Brick were hacked 450 per car for drying.

Eleven tunnel dryers accommodated 14 cars each, for a total drying capacity of about 70,000 brick. The tunnels were heated with waste heat from the kiln, augmented by gas. Drying time was about 3 days, and temperature at the hot end was 350°F. After drying, the brick were re-hacked on kiln cars, 1,800 brick per car. A circular tunnel kiln 155 feet

TABLE 145 Chemical Analyses: Gravell Brick Company Limited

Sample	blue clay 1	brown clay 2	top clay 3	Composite
Height above floor (*feet*)	bulk	14.0–18.0	18.0–20.0	14.0–20.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				59.38
Al_2O_3				16.6
Fe_2O_3	2.51	6.15	5.12	6.52
CaO	2.53	2.91	2.78	2.87
MgO				3.39
Na_2O				2.31
K_2O				3.07
TiO_2				0.62
CO_2				0.61
H_2O+				2.33
H_2O-				1.96
SO_3				0.39
TOTAL				100.1
Loss on ignition	4.41	4.19	4.73	5.21
Soluble salts	1.26	0.59	0.60	

TABLE 146 Mineral Analyses: Gravell Brick Company Limited
(A = abundant; B = moderate; C = minor; ND = not detected)

Sample	1	2	3	Composite
Height above floor (*feet*)	bulk	1.40–18.0	18.0–20.0	14.0–20.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	29	17	24	23
Calcite	1	ND	ND	ND
Dolomite	1	ND	ND	ND
Soda-lime feldspar	10	9	13	11
Potash feldspar	1	<0.5	3	2
Amphibole	1–10	1–10	1–10	1–10
Clay minerals				
Illite	B	B	B	B
Chlorite	A	B	B	B
Expanding minerals	C	B	B	B

TABLE 147 Ceramic Tests: Gravell Brick Company Limited

SAMPLE 1: 0.0′–14.0′ bulk sample, blue clay

Water of plasticity (*percent*)	22
Lineal drying shrinkage (*percent*)	3.9
Pyrometric cone equivalent	4–5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	4.2
Colour	tan	pink	salmon-buff
Hardness	moderately hard	almost hard	very hard
24-hour absorption (%)	17.1	16.6	7.0
5-hour boil absorption (%)	18.2	17.8	9.0
Specific gravity	1.78	1.79	2.07

REMARKS: Briquettes are marked by minor scumming on edges.

SAMPLE 2: 14.0′–18.0′ brown clay

Water of plasticity (*percent*)	29
Lineal drying shrinkage (*percent*)	6.6
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	1.0	7.6
Colour	pale salmon	salmon	red-brown
Hardness	moderately hard	hard	very hard
24-hour absorption (%)	17.0	15.5	3.4
5-hour boil absorption (%)	18.8	17.4	4.1
Specific gravity	1.80	1.86	2.31

REMARKS: Briquettes are overfired at cone 03.

SAMPLE 3: 18.0′–20.0′ top clay

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	3.1
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.2	5.2
Colour	pale salmon	salmon	dark red
Hardness	moderately soft	moderately hard	very hard
24-hour absorption (%)	18.8	17.2	7.0
5-hour boil absorption (%)	20.3	19.4	9.5
Specific gravity	1.73	1.74	2.07

REMARKS: Briquettes are overfired at cone 03.

long accommodated 24 cars. The kiln was gas fired, and operated at the rate of 12 cars per day; peak temperature was 1880°F. Three small beehive kilns could also be used.

GEOLOGY

Clay was excavated to a depth of 20 feet from a pit adjacent to the plant. The section consisted of 2 feet of dark red-burning surface clay, 4 feet of medium red-burning clay, and 14 feet of salmon-buff-burning clay. The clay is varved in layers 1 inch thick, each varve consisting predominantly of grey-blue silt or silty clay and an ⅛-inch layer of smooth plastic red-brown clay. The upper 6 feet of the clay section are oxidized to brown. The results of chemical, mineralogical, and ceramic testing of vertical channel samples of the upper 2-foot and 4-foot zones, and of a bulk sample of the 14-foot blue clay zone, are shown in tables 145, 146, 147.

J. H. HENDERSON

J. H. Henderson is the owner of a new plant at Henfryn, 8 miles southwest of Listowel. Mr. Henderson operated the plant of R. Thompson for several years before putting a new plant into production on adjoining ground in the fall of 1959. The 75-year-old Thompson plant has fallen into disuse, but clay for the new plant is still taken from the original pit. The new plant is in lot 34, concession VIII, Grey township, Huron county. The earlier plant is described by Montgomery (1930, p. 126).

Plant

About one million tile are produced yearly in sizes from 3½ to 8 inches. The plant employs 7 or 8 men for the 8-month working season.

The building is of concrete block and steel beam construction with a flat galvanized-iron roof. A 100 h.p. Caterpillar stationary diesel engine provides belt-drive for all equipment. The pit is worked once a year under contract and clay is stockpiled in the yard at the plant. Clay is taken from the bank by dragline. Trucking distance to the plant is about one-third of a mile. A rubber-tired Ford farm tractor with a small front-end bucket reclaims the clay as required and loads a single-shaft Bectel pug feeder. A double roll Parkhill disintegrator discharges onto a 22-inch belt

TABLE 148 Chemical Analyses: J. H. Henderson

Sample	1	2	3	Composite
Height above floor (*feet*)	−1.0 to 0.0	0.0–6.0	6.0–8.5	−1.0 to 8.5
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				58.36
Al_2O_3				10.4
Fe_2O_3	3.31	3.81	4.15	3.48
CaO	13.9	7.88	2.48	6.71
MgO				3.74
Na_2O				1.29
K_2O				2.66
TiO_2				0.58
CO_2				6.84
H_2O+				2.21
H_2O-				2.00
SO_3				0.42
TOTAL				98.7
Loss on ignition	17.15	11.57	7.33	11.35
Soluble salts	0.87	0.73	0.56	

TABLE 149 Mineral Analyses: J. H. Henderson
(A = abundant; B = moderate; ND = not detected)

Sample	1	2	3	Composite
Height above floor (*feet*)	−1.0 to 0.0	0.0–6.0	6.0–8.5	−1.0 to 8.5
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	22	30	30	33
Calcite	10	3	ND	3
Dolomite	20	11	<0.5	9
Soda-lime feldspar	1	3	4	5
Potash feldspar	<0.5	1	1	1
Amphibole	ND	ND	<1	<1
Clay minerals				
Illite	B	B	B	B
Chlorite	B	B	B	B
Expanding minerals	B	B	A	A*

*Montmorillonite

that feeds the F-R-H Plymouth Special extruder. Tile are produced at the rate of 1,700 or 1,800 per hour under a vacuum of 15 to 18 inches, and are cut by an F-R-H cutter. They are hacked in 3 tiers, 224 to a rack, and are transported to the dryers by forklift.

There are 3 waste-heat room dryers, 26 by 90 feet, with a capacity of 28,000 to 30,000 tile each. Drying time is usually 4 days. Two beehive kilns of 27-foot diameters hold 30,000 tile each. They are coal-fired to 1875°F and are operated on a 14-day cycle.

TABLE 150 Ceramic Tests: J. H. Henderson

SAMPLE 1: −1.0′ to 0.0′

Water of plasticity (*percent*)	22
Lineal drying shrinkage (*percent*)	5.0
Pyrometric cone equivalent	6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0	0.7	0.5
Colour	pale pink	cream	cream-white
Hardness	soft	moderately hard	almost hard
24-hour absorption (%)	20.3	18.3	18.4
5-hour boil absorption (%)	22.4	23.2	24.6
Specific gravity	1.64	1.62	1.62

SAMPLE 2: 0.0′–6.0′

Water of plasticity (*percent*)	23
Lineal drying shrinkage (*percent*)	6.0
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.4	0.4	0.2
Colour	dark salmon	salmon	salmon-brown
Hardness	moderately hard	almost hard	hard
24-hour absorption (%)	16.0	15.2	13.1
5-hour boil absorption (%)	17.8	18.6	17.0
Specific gravity	1.78	1.77	1.80

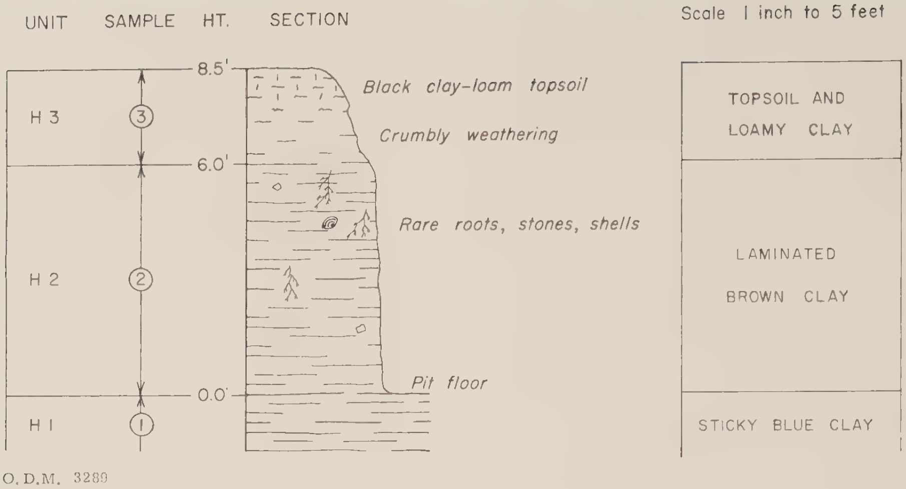
REMARKS: Briquettes are marked by a slight yellow scum at cone 03.

SAMPLE 3: 6.0′–8.5′

Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	6.9
Pyrometric cone equivalent	8

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	2.8
Colour	dark salmon	dark salmon	red-brown
Hardness	moderately hard	almost hard	very hard
24-hour absorption (%)	15.7	15.5	8.0
5-hour boil absorption (%)	18.5	18.5	11.3
Specific gravity	1.76	1.77	2.00

REMARKS: Briquettes are undeformed but slightly overfired at cone 03.



Unit		Thickness (*feet*)
H 3	CLAY: Olive-grey, drying buff; massive, silty, stoneless, crumbly; topped by black clay loam.	2.5
H 2	CLAY: Olive-grey, drying buff; silty, laminated in layers 1/16–1/4 inches thick; occasional fine roots, with heavy rusting along root-channels; rare shells and small stones.	6.0
H 1	CLAY: Blue-grey, drying pale grey; dense, sticky, stoneless; finely laminated (⅛-inch) with silt.	1+

Figure 37–J. H. Henderson, pit section.

GEOLOGY

The clay pit is located on the east bank of Boyle Creek, a mile south of its junction with the middle Maitland River, in lot 34, concession VIII, Grey township, Huron county. The deposit consists of finely laminated clay and silt, and occasional sand lenses, laid down on the flood plain of the river. The clay is unusual because of the importance of montmorillonite in the clay fraction. Dolomite predominates over calcite, but the content of both is greatly reduced by leaching in the zone of oxidation. Both the thickness of the deposit and the amount of leaching and oxidation suggest that the clay was accumulated over a fairly long period and at an early time, perhaps during the late Wisconsinan when this part of Ontario was an island surrounded by glacial ice.

An 8-foot section of clay is worked in a westerly direction over a length of 300 feet. A sticky blue-grey clay forms the floor of the pit, and the oxidized olive-grey clay lies above. The section is illustrated in figure 37 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 148, 149, 150.

HILL TILE LIMITED

One of the largest tile yards in southwestern Ontario is that of the brothers Maurice and Archie Hill of Stevenson. The pit and plant are located in lots 14 and 15, concession XIII, Tilbury East township, Kent county. The plant has been in operation since 1914. An early description is given by Montgomery (1930, pp. 127–128).

Plant

The plant operates the year round, with about 19 employees, and produces 4½ million tile annually. The products are all drain tile in 3- to 16-inch sizes.

Clay is taken from the bank by shovel and trucked ½ mile to the plant where an 18,000-cubic yard open air stockpile is built up during the summer months. A ⅜-yard Bucyrus Erie shovel loads two side-dump cars of 1½-yard capacity. These are hauled by a home-made 8-wheel-drive gasoline locomotive on rail up a small covered incline and dumped directly to a double-shaft pug feeder. In wet weather dry clay can be added to the feeder by a Hough Payloader using clay from a small covered stockpile. The feeder bin has a 2-inch plank bottom which is intended to break rather than cause damage to the knives if a

TABLE 151 Pit Section: Hill Tile Limited

Height above pit floor (*feet*)	Description	Thickness (*feet*)
2.7–3.5	TOPSOIL: Tough to loamy, grey-black, clay loam.	0.8
2.5–2.7	SAND: Lens of fine-grained, yellow, sand.	0.2
0.0–2.5	CLAY: Olive-grey to green-grey, mottled with rusty brown; massive, smooth, plastic; occasional fine roots; a few rounded pebbles and rare white angular limestone fragments.	2.5

large stone gets in by mistake. Clay is conveyed to a set of 22-inch Brewer conical rolls spaced ⅛-inch apart; large pebbles are rejected by a kick-out device.

The clay is carried by belt conveyor and is discharged to an F-R-H Junior double-shaft auger machine. De-airing is accomplished at 16–18 inches of vacuum. Large tile are extruded in a single stream, but 3- or 4-inch sizes are extruded in a double stream at the rate of 44 per minute (4-inch tile). The tile are cut by an F-R-H wire-cutter and hacked 118, in two tiers, per car. All major equipment is belt-driven by a 129 h.p. General Motors diesel motor.

A 25-track waste heat tunnel dryer 90 feet long has a drying capacity of 55,000 tile. Drying time is 2½ to 3 days and the ware is raised to 145°F at the hot end. Further drying capacity is available for large tile in room dryers above the tunnels. Five beehive kilns, with inside diameters of 26 feet, have a capacity of 22,500 tile each. They are coal-fired to a peak temperature of about 1800°F, and are worked on an 8-day cycle. The kilns and loading areas are completely housed in a steel building.

The red-burned tile are stocked in the yard or trucked from the kiln directly to the customer.

GEOLOGY

A 3½-foot section of partly re-sorted till has been removed over an area of 75 acres. Nothing is stripped from the top of the bank, but the area is periodically ploughed to check the growth of weeds and grass. A typical section is given above (in Table 151).

Olive-grey stony till lies below the floor of the pit. The results of chemical, mineralogical, and ceramic testing of a vertical 3½-foot channel sample are given in tables 152, 153, 154.

TABLE 152 Partial Chemical Analysis: Hill Tile Limited

Sample Height above floor (*feet*)	1 0.0–3.5
	(*percent*)
Fe_2O_3	5.57
CaO	1.80
Loss on ignition	8.48
Soluble salts	0.55

TABLE 153 Mineral Analysis: Hill Tile Limited
(A = abundant; C = minor; ND = not detected)

Sample Height above floor (*feet*)	1 0.0–3.5
	(*percent*)
Non-clay minerals	
Quartz	37
Calcite	<0.5
Dolomite	ND
Soda-lime feldspar	1
Potash feldspar	ND
Amphibole	ND
Clay minerals	
Illite	A
Chlorite	C
Expanding minerals	C

TABLE 154 Ceramic Tests: Hill Tile Limited

SAMPLE 1: 0.0′–3.5′

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	6.5
Pyrometric cone equivalent	10

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.1	3.5	8.1
Colour	salmon	dark salmon	red-brown
Hardness	very hard	very hard	very hard
24-hour absorption (%)	13.0	7.9	1.3
5-hour boil absorption (%)	13.9	9.5	2.2
Specific gravity	1.89	2.07	2.31

REMARKS: Briquettes are overfired at cone 03.

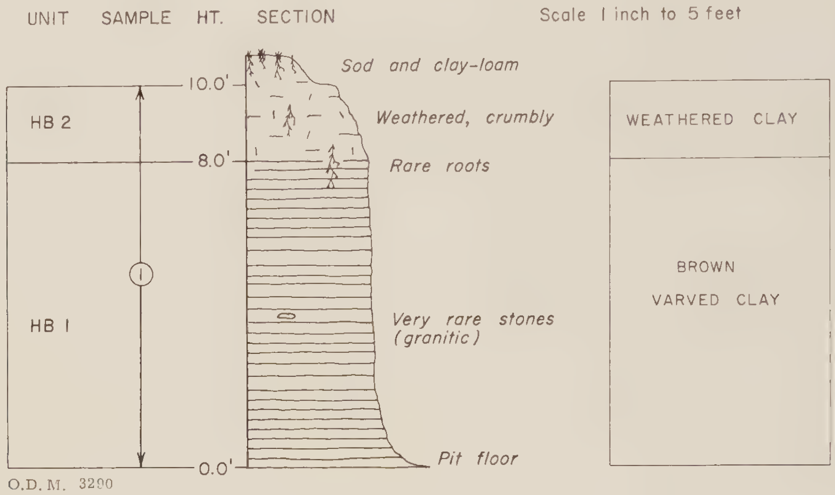
HOME BRICK LIMITED

E. Wyman is plant manager of a tile plant one mile southeast of Bracebridge. The plant was built in 1898 and was operated as the Watson Brick Company for many years. It is in lots 4 and 5, concession XIII, Draper township, district of Muskoka. Early descriptions of the plant are given by Baker (1906, p. 82–83) and Montgomery (1930, p. 140).

Plant

About 800,000 drain tile are produced in the 8- or 9-month season. Flue liners and brick are occasionally made. About 8 men are employed.

Less than 12 inches of topsoil and roots are stripped from the top of the clay bank. Clay is dug by power shovel and trucked a few hundred feet to a shed-covered storage area 100 by 40 feet. Sufficient clay can be stocked for two months continuous


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
Sod and clay-loam
10.0'
HB 2
Weathered, crumbly
8.0'
Rare roots
WEATHERED CLAY
BROWN
VARVED CLAY
1
HB 1
Very rare stones (granitic)
Pit floor
0.0'
O.D.M. 3290

Unit		Thickness (feet)
HB 2	CLAY: Medium brown, drying buff; uniform, massive, crumbly, stoneless.	2.0
HB 1	CLAY: Red-brown clay and olive-brown silt, drying pale brown and pale grey respectively; dense, tough; uniformly varved in layers $\frac{1}{4}$–$\frac{3}{8}$ inches thick; granitic pebbles very rare.	8.0

Figure 38–Home Brick Ltd., pit section.

TABLE 155 Chemical Analysis:
Home Brick Limited

Sample	1
Height above floor (*feet*)	0.0–10.0
	(*percent*)
SiO_2	58.16
Al_2O_3	16.6
Fe_2O_3	7.35
CaO	2.70
MgO	2.73
Na_2O	2.08
K_2O	4.03
TiO_2	0.86
CO_2	0.72
H_2O+	2.12
H_2O-	1.92
SO_3	0.62
TOTAL	99.89
Loss on ignition	3.93

TABLE 156 Mineral Analysis:
Home Brick Limited
(A = abundant; D = trace;
ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–10.0
	(*percent*)
Non-clay minerals	
Quartz	16
Calcite	ND
Dolomite	ND
Soda-lime feldspar	9
Potash feldspar	1
Amphibole	0.5–5
Clay minerals	
Illite	A
Chlorite	D
Expanding minerals	ND

TABLE 157 Ceramic Tests: Home Brick Limited

SAMPLE 1: 0.0′–10.0′

Water of plasticity (*percent*)	32
Lineal drying shrinkage (*percent*)	4.2
Pyrometric cone equivalent	2

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.9	6.1	11.4
Colour	salmon	dark salmon	dark red
Hardness	almost hard	hard	very hard
24-hour absorption (%)	19.2	11.4	0.14
5-hour boil absorption (%)	20.5	13.5	0.17
Specific gravity	1.73	1.98	2.45

REMARKS: Briquettes are overfired at cone 03.

operation. A ½-yard Davis front-end loader on a Ford farm tractor loads directly into a 9-foot Parkhill single-shaft pug feeder. An 18-inch belt delivers the clay to a 20-inch Parkhill rolls disintegrator; then to the F-R-H Plymouth Special de-airing extruder. Tile are extruded in a single stream under full vacuum (26 to 27 inches). They are cut by an F-R-H cutter; a Frey Universal cutter is used for brick. Tile are hacked in three tiers, 120 per car.

There are 3 tunnel dryers 100 feet long. Two contain 5 tracks each and the other has 4. Drying capacity is 28,000 tile. Waste-heat is recovered from the kilns and is augmented by a wood-burning furnace when necessary. The drying time is 48 hours and the temperature is 250°F at the hot end. There are 4 beehive kilns; 3 with diameters of 22 feet and capacities of 16,000 tile each, and 1 of 30-foot diameter with a capacity of 28,000 tile. They are fired with wood, or occasionally coal, to peak temperatures between 1760°F and 1850° F. They are kept on-fire for 55 hours and are turned over on a 7-day cycle.

GEOLOGY

Varved clay deposited by glacial Lake Algonquin is common in the valleys of the north and south branches of the Muskoka River and their tributaries. The pit of Home Brick Limited is cut into a clay terrace on the north flank of the valley of Sharp Creek, a tributary of the South Muskoka River. The excavation is rectangular, 60 by 100 feet, exposing 10-15 feet of clay. Less than 1 foot of clay-loam and roots is stripped from the surface as waste. The thickness of the clay deposit increases down the valley slope to 20 to 25 feet. The clay is underlain by sand, and on higher ground 500 feet north of the pit there are extensive deposits of sand and gravel.

A typical section through the clay bank is illustrated in figure 38 and described in accompanying notes. The results of chemical, mineralogical, and ceramic testing of a 10-foot vertical channel sample are given in tables 155, 156, 157.

F. W. HOWLETT AND SONS, LIMITED

A plant on the south side of Petrolia is managed by R. W. Howlett. It has been in the family possession continuously since it was built more than 80 years ago. The plant and clay pit are located in lots 12, concessions X and IX respectively, Enniskillen township, Lambton county. Early descriptions of the plant are given by Baker (1960, p. 74) and Montgomery (1930, p. 132).

Plant

The plant is operated for 10 months of the year and 12 men are employed. About 2 million tile are produced annually in 4- to 8-inch sizes.

The clay pit is about one mile from the plant. Excavation of the clay and truck haulage to the plant is done by contract. Two shed-covered storage areas, each 30 by 60 by 10 feet, hold sufficient clay to provide continuous operations during unfavourable weather. A John Deere caterpillar tractor equipped with front-end loader reclaims clay from the stockpile and dumps it into an American single-shaft pug feeder. Clay is carried by a 12-inch belt to a pair of Freeze smooth-faced rolls discharging directly into an American single-shaft auger machine. Tile are extruded in a single stream under a vacuum of 12 inches; they are cut by an F-R-H cutter and hacked in two tiers, 160 to the car.

Drying is accomplished in waste-heat room dryers capable of holding a total of 340 cars. Drying time is three to four days. Four beehive kilns, having diameters of 24 feet, hold 17,000 tile each. They are gas-fired to a peak temperature of 1800°F and are turned over on a 7-day cycle.

The orange-red tile are stored in the yard and shipped by truck.

GEOLOGY

Massive brown clay occurs on the flood plain of Bear Creek, a tributary of the North Sydenham River. At Petrolia the creek valley is broad and shallow,

TABLE 158 Partial Chemical Analysis:
F. W. Howlett & Sons, Limited

Sample	1
Height above floor (*feet*)	0.0–5.0
	(*percent*)
Fe_2O_3	5.77
CaO	2.88
Loss on ignition	9.12
Soluble salts	0.54

TABLE 159 Mineral Analysis:
F. W. Howlett & Sons, Limited
(A = abundant; B = moderate; C = minor;
ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–5.0
	(*percent*)
Non-clay minerals	
Quartz	33
Calcite	<0.5
Dolomite	1
Soda-lime feldspar	2
Potash feldspar	<0.5
Amphibole	ND
Clay minerals	
Illite	A
Chlorite	B
Expanding minerals	C

TABLE 160 Ceramic Tests: F. W. Howlett & Sons, Ltd.

SAMPLE 1: 0.0′–5.0′

Water of plasticity (*percent*)	28
Lineal drying shrinkage (*percent*)	6.2
Pyrometric cone equivalent	6

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	2.8	6.4
Colour	salmon	dark salmon	dark brown
Hardness	hard	very hard	very hard
24-hour absorption (%)	15.5	11.0	0.15
5-hour boil absorption (%)	16.9	13.2	0.23
Specific gravity	1.80	1.92	2.32

REMARKS: Briquettes are attractive and well-fired at cones 010 and 06, but are overfired at cone 03.

and a 6-foot thickness of clay extends across the valley width of 1,000 feet. Clay for the tile plant was formerly taken from an irregularly shaped pit, 300 feet long, on the north bank of the creek, immediately south of the plant. Similar clay is now obtained from a new pit about one mile from the plant. Sod is stripped from the surface, and clay is removed to a depth of 5 feet, which is the normal river level at this point.

The clay is Recent in age, and is derived from the surrounding till plains by erosion and run-off of surface waters. Leaching of carbonate minerals before and during transport has greatly reduced the lime content. The clay is a uniform, sandy, loamy-textured medium-brown clay with a faint grey-green mottling in the lower part. White shells are occasionally present, but roots are rare and there are no stones. The 6-foot layer of brown clay rests on grey silt in which shells and wood fragments are fairly common and there are rare small pebbles. The results of chemical, mineralogical, and ceramic testing of a vertical channel sample of the upper 5 feet of clay are given in tables 158, 159, 160.

HUNTSVILLE BRICK WORKS

Don Little is the owner of a soft-mud brick plant located near the southern end of the Huntsville by-pass on no. 11 highway. The plant was built in 1900, and was purchased by C. H. Stevens in 1912 and by the present owner in 1964. W. D. Gore is the plant manager. The plant is in lot 8, concession I, Chaffey township, District of Muskoka. Early descriptions are given by Baker (1906, p. 89) and Montgomery (1930, p. 140).

Plant

The plant is being modernized under the new ownership and it is planned to increase production to 2 million soft-mud brick annually. The working season is 6–7 months and 14 men are employed. This is the only remaining plant in Ontario specializing in soft-mud brick. The product is an attractive salmon-pink to medium-red brick.

A Massey Harris tractor with interchangeable front-end loader and forklift attachments excavates clay from the pit and hauls it 150 feet to a small covered stockpile in the plant. Clay is shovelled manually to a conveyor that feeds a single-shaft Parkhill pug mill, but a pug feeder is planned shortly to replace the

ODM7464

Photo 41–Huntsville Brick Works; plant 1965.

Table 161 Partial Chemical Analysis: Huntsville Brick Works

Sample	1
Height above floor (*feet*)	bulk
	(*percent*)
Fe_2O_3	5.29
CaO	3.29
Loss on ignition	1.92
Soluble salts	0.51

Table 162 Mineral Analysis: Huntsville Brick Works
(A = abundant; B = moderate; ND = not detected)

Sample	1
Height above floor (*feet*)	bulk
	(*percent*)
Non-clay minerals	
Quartz	30
Calcite	ND
Dolomite	2
Soda-lime feldspar	10
Potash feldspar	1
Amphibole	1–10
Clay minerals	
Illite	A
Chlorite	ND
Expanding minerals	B

Table 163 Ceramic Tests: Huntsville Brick Works

SAMPLE 1: bulk	
Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	2.5
Pyrometric cone equivalent	2

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.5	8.0
Colour	pale salmon	salmon-pink	dark red
Hardness	soft	moderately hard	very hard
24-hour absorption (%)	16.7	15.4	1.1
5-hour boil absorption (%)	18.0	16.7	1.2
Specific gravity	1.79	1.83	2.38

REMARKS: Briquettes are overfired at cone 03.

manual loading. Brick are formed in a Parkhill Martin-A-Brick machine making five brick with each cycle in sand-dusted wood moulds. The brick are hacked on steel dryer cars mounted on rails; each car is nine racks high and holds 270 brick. The pug mill and brick machine are operated by belt-drive from a 30-h.p. electric motor.

Six single-track tunnel dryers 100 feet long replace the original open-air drying sheds. They are oil-fired, and the brick are dried for 2–2½ days at 150–160°F. Two beehive kilns have capacities of 35,000 brick each, and a rectangular downdraft kiln holds 55,000 brick. They are housed in wood frame structures with corrugated iron roofs. Slab-wood is used for fuel and the peak firing temperature is 1850°F. Kilns are on-fire for 5½–7 days, and are turned over on a 2–3 week cycle.

GEOLOGY

Varved clay deposited from glacial Lake Algonquin is common in the lake basins and river valleys of the Huntsville and Bracebridge areas. At the

Huntsville Brick Works 12–15 feet of thinly varved brown clay and silt overlies silt and sand. The pit is dish-shaped, about 150 feet in diameter and cut to a depth of 8 feet into the side of a low clay terrace. The section was poorly exposed in 1961 because at that time the clay was being removed by tractor-drawn scraper. Chemical, mineralogical, and ceramic test results on a bulk sample of the clay are given in tables 161, 162, 163.

D. A. JANES AND SON, LIMITED

D. A. Janes is owner of a tile plant on the north side of no. 2 highway, 2 miles west of Delaware; it has been in the family ownership since 1880. Delaware is 10 miles west of London. The plant is in lot 20, range I North, Caradoc township, Middlesex county. Early descriptions are given by Baker (1906, p. 79) and Montgomery (1930, p. 136).

Plant

Thirty kilns, or about ½ million tile, are produced during the 8-month working season. The cream-buff tile are made in sizes from 4 to 12 inches. About 25,000 brick are produced each year. H. C. Janes is the superintendent and ten men are employed.

The buildings are of corrugated steel on a wood frame, and are well maintained. A large fuel oil-burning John Deere tractor supplies belt-drive for all equipment, replacing the original Leonard steam engine. Excavation of the clay bank is contracted once a year and a stockpile is built up beneath a

TABLE 164 Chemical Analyses: D. A. Janes & Son, Limited

Sample	1	2	Composite
Height above floor (*feet*)	5.0–12.0	12.0–18.0	5.0–18.0
	(*percent*)	(*percent*)	(*percent*)
SiO_2			42.65
Al_2O_3			10.8
Fe_2O_3	4.39	5.29	4.21
CaO	16.8	15.7	16.5
MgO			3.65
Na_2O			0.99
K_2O			3.00
TiO_2			0.60
CO_2			13.21
H_2O+			2.32
H_2O-			1.14
SO_3			0.27
TOTAL			99.3
Loss on ignition	17.20	16.70	17.16
Soluble salts	0.80	0.98	

TABLE 165 Mineral Analyses: D. A. Janes & Son, Limited (A = abundant; B = moderate; D = trace; ND = not detected)

Sample	1	2	Composite
Height above floor (*feet*)	5.0–12.0	12.0–18.0	5.0—18.0
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	18	17	20
Calcite	24	24	22
Dolomite	6	4	7
Soda-lime feldspar	3	3	4
Potash feldspar	<0.5	ND	1
Amphibole	ND	ND	ND
Gypsum	D		
Clay minerals			
Illite	A	A	B
Chlorite	B	B	B
Expanding minerals	D	B	B*

*Montmorillonite

TABLE 166 Ceramic Tests: D. A. Janes & Son, Limited

SAMPLE 1: 5.0′–12.0′

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	6.0
Pyrometric cone equivalent	3

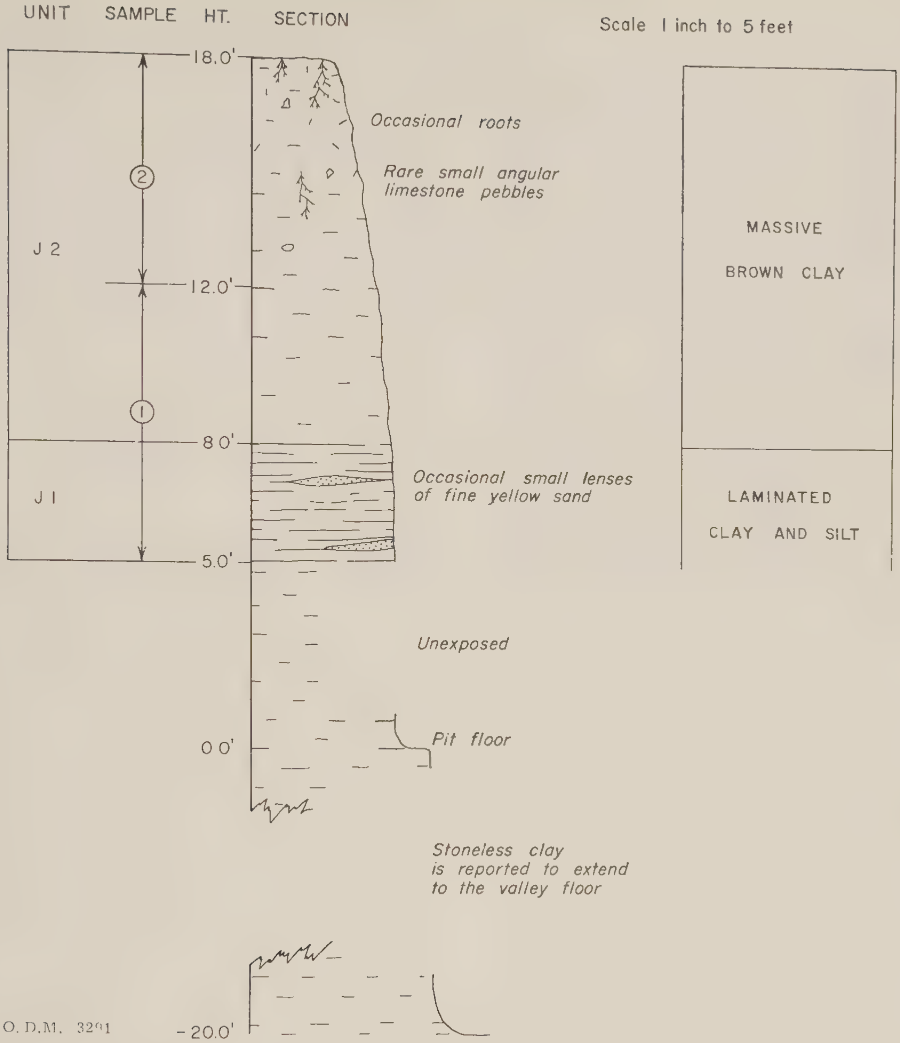
	Cones		
	(1660°F)	(1840°F)	(1980°F)
Lineal firing shrinkage (%)	1.6	1.6	2.8
Colour	pale salmon	cream	buff
Hardness	almost hard	hard	hard
24-hour absorption (%)	17.8	16.4	14.6
5-hour boil absorption (%)	18.8	17.4	17.9
Specific gravity	1.74	1.74	1.79

SAMPLE 2: 12.0′–18.0′

Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	6.0
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.9	2.1	3.2
Colour	pale salmon	cream-pink	buff
Hardness	almost hard	hard	very hard
24-hour absorption (%)	16.3	16.5	14.7
5-hour boil absorption (%)	16.8	16.9	15.8
Specific gravity	1.78	1.78	1.83

REMARKS: Briquettes are slightly overfired at cone 03.


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
18.0'
12.0'
8.0'
5.0'
0.0'
-20.0'
J 2
J 1
②
①
Occasional roots
Rare small angular limestone pebbles
Occasional small lenses of fine yellow sand
Unexposed
Pit floor
Stoneless clay is reported to extend to the valley floor
MASSIVE
BROWN CLAY
LAMINATED
CLAY AND SILT
O. D.M. 3291

Unit		Thickness (*feet*)
J 2	Clay: Medium brown, drying buff, mottled with blue-green; massive, crumbly, silty; rare angular limestone pebbles; occasional fine roots.	10.0
J 1	Clay: Medium brown, drying buff-grey; silty, stoneless; finely laminated in layers ⅛-inch thick; fine yellow sand or silt on lamination planes and in lenses.	3+

Figure 39—D. A. Janes and Son Ltd., pit section.

shed cover, 30 by 60 feet, on the pit floor. One of two Fordson Major farm tractors, equipped with chains or half-tracks and front-end bucket, reclaims the clay from storage and loads a 1-yard side-dump Baird rail car. The car is winched 300 feet up a slight incline to the plant. Clay is fed manually into a set of 24-inch Parkhill smooth rolls. A revolving toothed shaft above the nip of the rolls is effective in breaking up hard clay lumps. A short 14-inch bucket-type conveyor feeds a Parkhill single-shaft pug mill, and tempering water is added at this point as required. A Baird combined smooth roll and extruder produces tile in a single stream without de-airing. Cut-off is by a Bensings Automatic Clay Cutter. Tile are hacked in three tiers, 100 per rack, and are moved by Hyster model 2A gasoline-powered rack lifts.

Three rooms, each 140 by 30 feet, have a total drying capacity of 80,000 tile. Natural drying is sometimes assisted by Jaeger and Salamander-type heaters. The average drying time is one week. Two beehive kilns, 22 and 26 feet in diameter, hold 14,000 and 20,000 tile respectively. They are fired with wood and coal and are operated on a 12-day cycle.

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Photo 42—D. A. Janes and Son Limited; kilns 1965.

GEOLOGY

Brown silty clay deposited in the valley of a small tributary of the Thames River is considered by Dreimanis (1964, map) to have accumulated at the time of Lake Maumee, a forerunner of glacial Lake Whittlesey. The pit face is 300 feet long, and is advancing into the west wall of the valley. An 18-foot section is exposed in the pit, but stoneless clay is reported to continue a further 20 feet to the level of the valley floor. The section is illustrated in figure 39 and described in accompanying notes. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 164, 165, 166.

EARL LINDSAY AND SONS, LIMITED

G. C. Lindsay is the owner of a plant half-way between Dresden and Wallaceburg. It is located in lot 24, concession II, Chatham Gore township, Kent county. An early description of the plant is given by Montgomery (1930, p. 130).

Plant

Three million clay tile are produced in a 10-month season. All sizes from 4- to 10-inch are made from clay, while larger tile and sewer pipe are made from concrete in a new plant across the road. C. Morrison is the superintendent of the clay plant and eighteen men are employed in it. The plant is well constructed of brick and structural tile and has asphalt roofing.

An Insley 1-yard dragline loads trucks at the pit for the 2-mile haul to the plant. Two Caterpillar bulldozers remove sod and minor topsoil, and maintain the pit in a very tidy condition. A 200-ton stockpile is maintained in an enclosed storage area at the plant. A Parkhill single-shaft feeder and belt conveyor delivers clay to a 24-inch Steele rolls disintegrator. The clay drops directly to a Parkhill 4-shaft pug feeder and is then conveyed to a set of closely spaced Steele 22-inch smooth rolls. Extrusion is by an F-R-H Hummer de-airing double-shaft auger

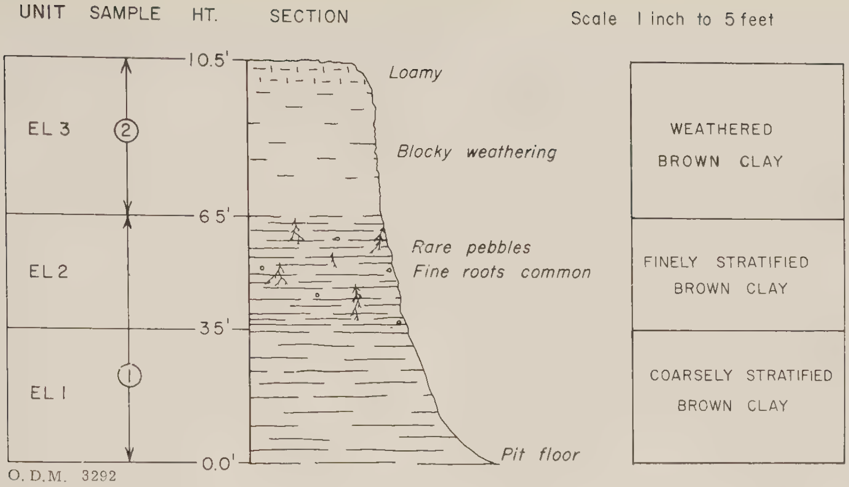
TABLE 167 Chemical Analyses: Earl Lindsay & Sons, Limited

Sample	1	2	Composite
Height above floor (*feet*)	0.0–6.5	6.5–10.5	0.0–10.5
	(*percent*)	(*percent*)	(*percent*)
SiO_2			53.71
Al_2O_3			13.2
Fe_2O_3	4.93	6.40	5.70
CaO	9.50	3.89	7.50
MgO			3.50
Na_2O			0.75
K_2O			2.80
TiO_2			0.73
CO_2			6.83
H_2O+			2.50
H_2O-			1.88
SO_3			0.70
TOTAL			99.80
Loss on ignition	14.03	10.08	11.82
Soluble salts	0.74	0.71	

TABLE 168 Mineral Analyses: Earl Lindsay & Sons, Limited (A = abundant; B = moderate; C = minor; ND = not detected)

Sample	1	2	Composite
Height above floor (*feet*)	0.0–6.5	6.5–10.5	0.0–10.5
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	27	31	31
Calcite	9	1	6
Dolomite	9	1	5
Soda-lime feldspar	3	1	2
Potash feldspar	2	ND	1
Amphibole	<1	ND	ND
Clay minerals			
Illite	A	A	A
Chlorite	B	B	B
Expanding minerals	C	C	B*

*Montmorillonite



Unit		Thickness *(feet)*
EL 3	CLAY: Medium orange-brown, drying pale brown; uniform, tough, stoneless; massive; blocky weathering, loamy at top.	4.0
EL 2	CLAY: Medium orange-brown, with minor pale pink mottlings, and grey-green fracture stains; rubbery texture; thinly stratified in layers $\frac{1}{4}$–$\frac{3}{8}$ inches thick, brown clay and yellow silt; fine roots common; rare subangular pebbles.	3.0
EL 1	CLAY: Medium orange-brown, with grey-green fracture stains; smooth (except for silt laminae), stoneless; stratified in layers $\frac{1}{2}$–2 inches thick, with a fine, $\frac{1}{8}$- to $\frac{1}{4}$-inch, lamination superimposed; laminae of yellow and grey silt up to $\frac{1}{4}$-inch thick; fine roots common.	3.5

Figure 40—Earl Lindsay and Sons Ltd., pit section.

TABLE 169 Ceramic Tests: Earl Lindsay & Sons, Limited

SAMPLE 1: 0.0′–6.5′

Water of plasticity (*percent*)	23
Lineal drying shrinkage (*percent*)	5.5
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.4	5.1
Colour	pale salmon	pale salmon	pink-brown
Hardness	hard	hard	very hard
24-hour absorption (%)	16.3	14.0	5.8
5-hour boil absorption (%)	17.4	15.8	6.1
Specific gravity	1.74	1.77	2.00

REMARKS: Fired briquettes are marked by a slight yellow scum.

SAMPLE 2: 6.5′–10.5′

Water of plasticity (*percent*)	30
Lineal drying shrinkage (*percent*)	7.3
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.2	0.7	7.9
Colour	salmon	dark salmon	red-brown
Hardness	very hard	very hard	very hard
24-hour absorption (%)	12.6	7.4	0.17
5-hour boil absorption (%)	13.3	7.8	0.25
Specific gravity	1.86	2.02	2.31

REMARKS: Briquettes are overfired but not deformed at cone 03.

machine. A double stream is extruded for 4-inch tile; a single stream for larger tile. The machine can produce 3,500 of the small tile per hour. De-airing is accomplished at about 15 inches of vacuum. The clay stream is cut by a Steele cutter and the tile are hacked in three tiers, 252 to a car.

There are eight tunnel dryers with a capacity of seventeen cars each. Gradient of the track is sufficient to facilitate manual movement of the cars, and 18,000 to 20,000 tile are pulled daily. Waste heat from the kilns, plus auxiliary gas heating if required, maintains a temperature of 130°F at the cold end and 200°F at the discharge end. Large tile can be dried slowly in a room above the tunnels. Four beehive kilns with diameters of 30 feet hold 32,000 tile each. They are coal-fired. Each kiln operates on a 12-day cycle, and the production averages five kilns every two weeks.

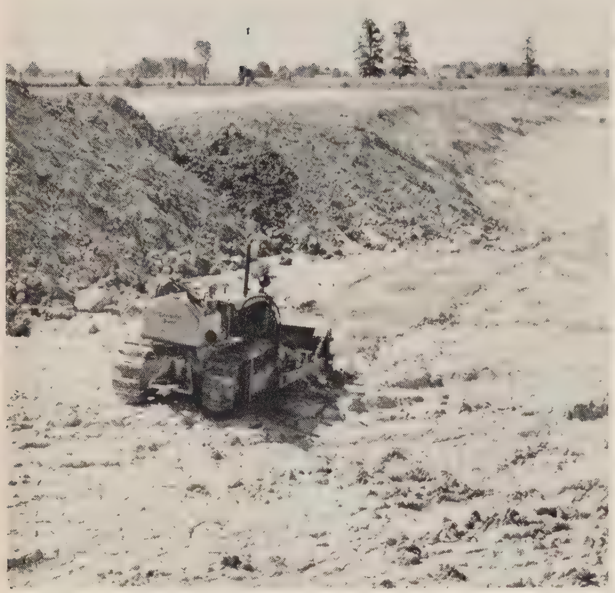


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Photo 43–Earl Lindsay and Sons Limited; clay pit 1965.

GEOLOGY

The clay pit lies in the north half of lot 23, concession III, Chatham Gore township, 1½ miles north of the plant. It is located adjacent to Otter Creek, a tributary of the Sydenham River, in flat farming country that formerly was the bed of an early, high-level, stage of Lake St. Clair. Ten feet of brown stratified clay and silt exposed in the pit face is believed to have been deposited by this lake rather than the ancestral glacial lakes Whittlesey and Warren (Chapman and Putnam 1951, p. 176). The pit is 700 feet by 100 feet, and has a 10-foot face cut eastward from the creek; the creek provides drainage for the pit. A 10-foot section is illustrated in figure 40 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of two vertical channel samples are given in tables 167, 168, 169.

AMOS C. MARTIN, LIMITED; PARKHILL

In 1962 A. C. Martin established a new tile plant on the site of the former H. C. Baird soft-mud brick plant at Parkhill. The plant is in lot 7, concession XX, Williams West township, Middlesex county, ⅛ mile west of the Parkhill Brick Company Limited. Mr. Martin also operates a tile plant near Wallenstein in Wellington county. The early Baird plant is described by Baker (1906, p. 80) and Montgomery (1930, p. 137).

TABLE 170 Chemical Analyses: Amos C. Martin, Ltd., Parkhill

Sample	1	2	Composite
Height above floor (*feet*)	0.0–5.0	5.0–9.0	0.0–9.0
	(*percent*)	(*percent*)	(*percent*)
SiO_2			39.8
Al_2O_3			7.90
Fe_2O_3	2.89	3.50	3.02
CaO	16.83	14.79	16.4
MgO			8.20
Na_2O			0.75
K_2O			2.22
TiO_2			0.39
CO_2			19.28
H_2O+			1.62
H_2O-			0.70
SO_3			0.32
TOTAL			100.7
Loss on ignition	23.24	21.25	21.96
Soluble salts	0.69	0.73	

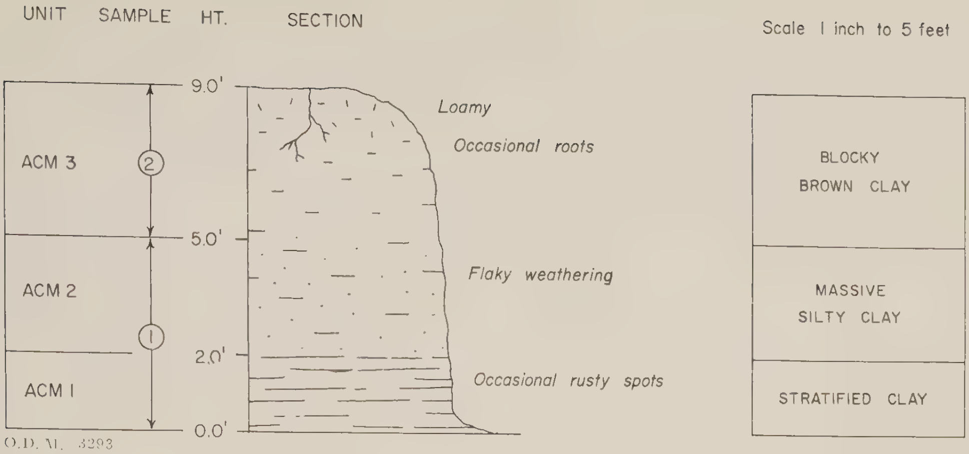
TABLE 171 Mineral Analyses: Amos C. Martin, Ltd., Parkhill (B = moderate; C = minor)

Sample	1	2
Height above floor (*feet*)	0.0–5.0	5.0–9.0
	(*percent*)	(*percent*)
Non-clay minerals		
Quartz	24	29
Calcite	12	10
Dolomite	30	24
Soda-lime feldspar	3	2
Potash feldspar	1	1
Clay minerals		
Illite	B	B
Chlorite	C	C
Expanding minerals	C	C

Plant

The plant is operated the year round and about 2 million tile are produced. Twenty men are employed.

Clay is taken from the bank by a 2-yard Hough Payloader. A small tractor loader reclaims the clay from a covered storage area at one end of the plant and scrapes it into a sub-floor pug mill feeder. The clay is carried by conveyor belt to a Parkhill rolls disintegrator and a F-R-H 24 by 24-inch smooth double-roll crusher. The clay is further pugged in a Parkhill single-shaft mill, then in an F-R-H Plymouth Special combined pug mill and extruder. Water may be added at any of the three pugging stages. Extrusion is in a single stream, at the rate of 1,600–1,700


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
9.0'
5.0'
2.0'
0.0'
ACM 3
ACM 2
ACM 1
②
①
Loamy
Occasional roots
Flaky weathering
Occasional rusty spots
BLOCKY BROWN CLAY
MASSIVE SILTY CLAY
STRATIFIED CLAY
O.D.M. 3293

Unit		Thickness *(feet)*
ACM 3	CLAY: Medium brown, drying buff; silty, massive, blocky, stoneless; a few fine roots; top 1-foot is grey-brown and loamy.	4.0
ACM 2	CLAY: Medium brown, drying buff; silty, massive, stoneless; flaky weathering; minor rusty mottling.	3.0
ACM 1	CLAY: Pink-brown, drying buff; smooth, with silty veneers, tough; irregularly stratified in layers ¼–2 inches thick; occasional rusty spots.	2.0

Figure 41—Amos C. Martin Ltd., Parkhill pit section.

TABLE 172 Ceramic Tests: Amos C. Martin, Ltd., Parkhill

SAMPLE 1: 0.0′–5.0′

Water of plasticity (*percent*)	19
Lineal drying shrinkage (*percent*)	4.7
Pyrometric cone equivalent	7

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.2	1.7	1.8
Colour	tan	cream	cream-white
Hardness	almost hard	almost hard	almost hard
24-hour absorption (%)	25.2	23.3	20.6
5-hour boil absorption (%)	26.2	27.9	28.8
Specific gravity	1.54	1.50	1.49

SAMPLE 2: 5.0′–9.0′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	4.8
Pyrometric cone equivalent	7

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing expansion (%)	0.3	0.7	0.5
Colour	tan	cream	cream-buff
Hardness	almost hard	almost hard	almost hard
24-hour absorption (%)	22.5	22.0	19.0
5-hour boil absorption (%)	24.4	24.6	25.9
Specific gravity	1.60	1.55	1.57

REMARKS: Smooth-textured, attractive briquettes.

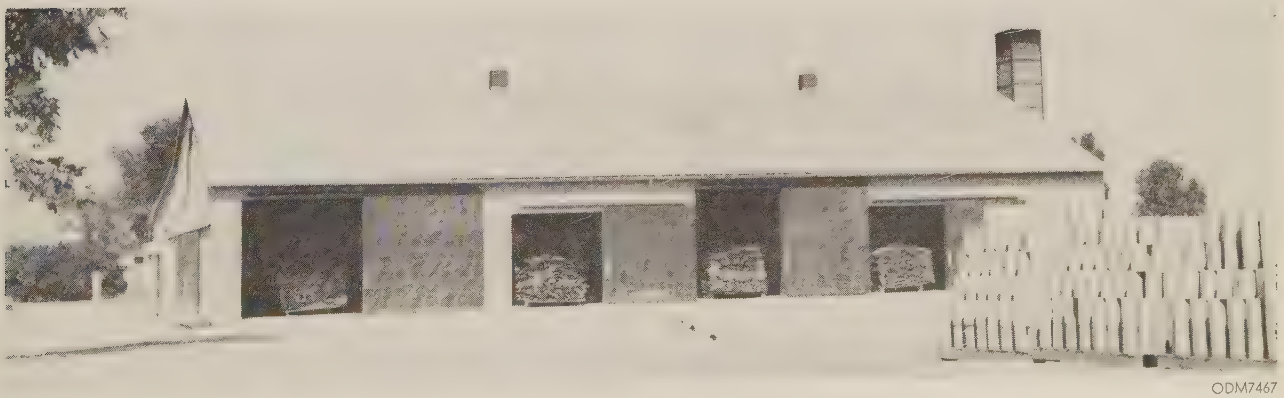


Photo 44—Amos C. Martin Limited; Parkhill plant 1965.

tile per hour, under a vacuum of 20 inches. Tile are cut by an F-R-H wire-cutter, and are hacked in three tiers, 210 per rack.

There are two-waste-heat room dryers, each with a capacity of 23,000 tile; drying time is three to four days. Two beehive kilns, 27 feet in diameter, share a common exhaust stack. Each kiln holds 25,000 tile and burns hard maple. Peak firing temperature is 2000°F at the top and 1700°F at the bottom of the kiln. The production cycle averages two kilns per week.

GEOLOGY

In 1962 a drainage channel, nine feet deep, had been excavated across the property 200 feet south of the plant. Silty clay removed during this work was stockpiled; it formed the major part of the feed to the plant. This clay is now mixed with a denser, more plastic, red-burning clay that is found in a few small scattered depressions on the property. Hamilton shale from the vicinity of Arkona may also be used, if reserves of the plastic clay prove insufficient.

The silty clay was deposited near the shoreline of glacial Lake Warren. Lenses of sand on the nearby Parkhill Brick property are shallow, near-shore, features. The nine-foot section on the A. C. Martin property is illustrated in figure 41 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 170, 171, 172.

AMOS. C. MARTIN, LIMITED; WALLENSTEIN

A. C. Martin is the manager of a tile plant just across the road from the N. S. Bauman plant. The road also marks the county boundary, so that the Martin plant is in lot 20, concession I, Peel township, Wellington county. The plant is over 70 years old and has been owned by the Martin family since 1919. An early description is given by Montgomery (1930, p. 157).

Plant

The Martin and Bauman plants are very similar. The Martin plant is older but has been kept up to date in equipment and design. Five million tile are produced annually in 4- to 10-inch sizes. Twelve- and 14-inch sizes are made in 18-inch lengths. Forty men are employed for the full year.

Clay is loaded into two trucks by a ½-yard Unit

TABLE 173 Chemical Analysis: Amos C. Martin, Limited

Sample	1
Height above floor (*feet*)	0.0–7.0
	(*percent*)
SiO_2	41.52
Al_2O_3	8.51
Fe_2O_3	4.13
CaO	16.9
MgO	4.25
Na_2O	0.99
K_2O	2.75
TiO_2	0.48
CO_2	15.66
H_2O+	1.52
H_2O-	1.32
SO_3	0.20
TOTAL	98.2
Loss on ignition	19.27
Soluble salts	0.80

TABLE 174 Mineral Analysis: Amos C. Martin, Limited
(B = moderate; C = minor)

Sample	1
Height above floor (*feet*)	0.0–7.0
	(*percent*)
Non-clay minerals	
Quartz	23
Calcite	20
Dolomite	13
Soda-lime feldspar	3
Potash feldspar	1
Clay minerals	
Illite	B
Chlorite	C
Expanding minerals	B*

*Montmorillonite.

TABLE 175 Ceramic Tests: Amos C. Martin, Limited

SAMPLE: 0.0′–7.0′

Water of plasticity (*percent*)	22
Lineal drying shrinkage (*percent*)	4.2
Pyrometric cone equivalent	2–3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.0	0.4	0
Colour	tan	light tan	cream
Hardness	soft	soft	almost hard
24-hour absorption (%)	23.9	25.3	24.4
5-hour boil absorption (%)	25.9	28.1	27.3
Specific gravity	1.63	1.60	1.61

diesel dragline. The haul to the plant is about 300 feet. An 8,000-yard stockpile is completely enclosed in a wood frame building 170 by 80 feet. Clay is reclaimed by a 3-wheel Wagner Scoopmobile of 1-yard capacity and dumped directly into a Parkhill double-shaft pug feeder. It is discharged to an 18-inch Parkhill double-toothed rolls disintintegrator followed by a closely spaced pair of J. C. Steele smooth rolls, 30 inches in diameter with an 18-inch face. The clay stream is partitioned between two single-shaft pug mills, each feeding an F-R-H Plymouth Special auger machine. Tile are extruded at the rate of 1,800 per hour in a single stream under a vacuum of 15 inches. They are cut by Plymouth cutters and hacked in three tiers, 200 tile per rack. Tile are moved to the dryers by rack-lift trucks.

Six waste-heat room dryers have a total capacity of 135,000 tile. The tile are dried slowly by gradually raising the temperature to 140°F over a period of four days. Waste heat is recovered from the crown of the kilns and enters the dryers through slots in the floor. Six beehive kilns hold 20,000 to 26,000 tile each. They are coal-fired to a peak temperature of 1800°F. The burning cycle lasts 70 to 80 hours and the turnover cycle is seven days. The tile are fired to a cream-yellow colour streaked with pink.

A fleet of four semi-trailers and three platform trucks deliver the tile from yard storage. Mr. Martin also operates tile-laying equipment.

GEOLOGY

The clay pit lies just northwest of the plant, in the same topographic depression that includes the N. S. Bauman pit. The shallow, south-trending, depression is a drainage course to the Conestogo River; it lies in flat terrain that is mantled by a thin layer of till. Low hills to the east are kames of sand and gravel, and an apron of outwash sand just reaches the clay depression in a few places. The pit face exposes six feet of finely laminated, medium olive-grey, clay with occasional rusty patches; it dries to a cream-grey colour. The clay underlies 8–12 inches of sandy loam and sod, and overlies 2–4 inches of medium-grained yellow sand. Grey varved clay lies below, as at the Bauman pit, but it is not used for tile. The results of chemical, mineralogical, and ceramic testing of a 7-foot vertical channel sample, that includes the olive-grey laminated clay and the loamy topsoil, are given in tables 173, 174, 175.

W. J. McFARLANE & SONS LIMITED

W. J. McFarlane has owned and operated a plant on the north side of Forest since 1926. It is located in lot 39, along the south boundary of Bosanquet township, Lambton county. An early description is given by Montgomery (1930, p. 134).

Plant

The plant operates the year round and employs 8-10 men. Two million tile are produced annually, and a few structural tile are also made.

Clay was formerly dug by a Universal No. 35 crawler dragline, but is now taken from the bank by a No. 210 Case tractor and backhoe. It is trucked about 700 feet to a small stockpile at the plant and is reclaimed as required by a ½-yard Oliver front-end loader. From a Parkhill single-shaft pug feeder the clay passes through a pair of 12-inch diameter, 24-inch, smooth rolls set at a spacing of ¼-inch. It is then conveyed to a second pair of smooth rolls, 32 inches in diameter by 12 inches, set at minimum spacing to further reduce the size of pebbles. Mr. McFarlane reports that the addition of three shovelfulls of salt per truckload of clay effectively minimizes lime popping caused by the small proportion of limestone pebbles that are uniformly distributed in the clay bank. Clay drops directly from the large rolls to a Parkhill single-shaft pug mill where tempering water is added as required. An F-R-H double-shaft pug extruder is capable of producing about 1,600 tile per hour. Using a double stream on 4-inch tile the production can be raised as high as 2,000 per hour. De-airing is accomplished at 18 inches of vacuum. Tile are cut by a Fate machine, and are hacked in three tiers, 175 per car. All machinery is driven by a 160 h.p. General Motors diesel motor.

Drying is accomplished in 10 waste-heat room dryers containing 3 tracks each. The dryers are 115 feet feet long and have a total capacity of 90,000 tile. Drying time is two days at 150°F. There are three beehive kilns, 23–26 feet in diameter, holding an average of 20,000 tile each. They are coal-fired to peak temperatures of 1900°F at the top and at least 1600°F at the bottom. The kilns operate on a seven-day cycle.

The red-burned tile are stored in the yard and shipped by truck.

TABLE 176 Partial Chemical Analysis: W. J. McFarlane & Sons, Limited

Sample	1
Height above floor (*feet*)	0.0–4.0
	(*percent*)
Fe_2O_3	5.37
CaO	7.38
Loss on ignition	12.60
Soluble salts	0.73

TABLE 177 Mineral Analysis: W. J. McFarlane & Sons, Limited
(A = abundant; B = moderate; C = minor; ND = not detected)

Sample	1
Height above floor (*feet*)	0.0–4.0
	(*percent*)
Non-clay minerals	
Quartz	34
Calcite	4
Dolomite	4
Soda-lime feldspar	1
Potash feldspar	2
Amphibole	ND
Clay minerals	
Illite	A
Chlorite	B
Expanding minerals	C

TABLE 178 Ceramic Tests: W. J. McFarlane & Sons, Limited

SAMPLE 1: 0.0′–4.0′	
Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	6.8
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.4	4.8
Colour	salmon	salmon	dark brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	16.5	14.3	2.2
5-hour boil absorption (%)	17.8	17.3	3.0
Specific gravity	1.75	1.77	1.78

REMARKS: Briquettes are overfired at cone 03.

ODM7468

Photo 45—W. J. McFarlane and Sons Limited; plant 1965.

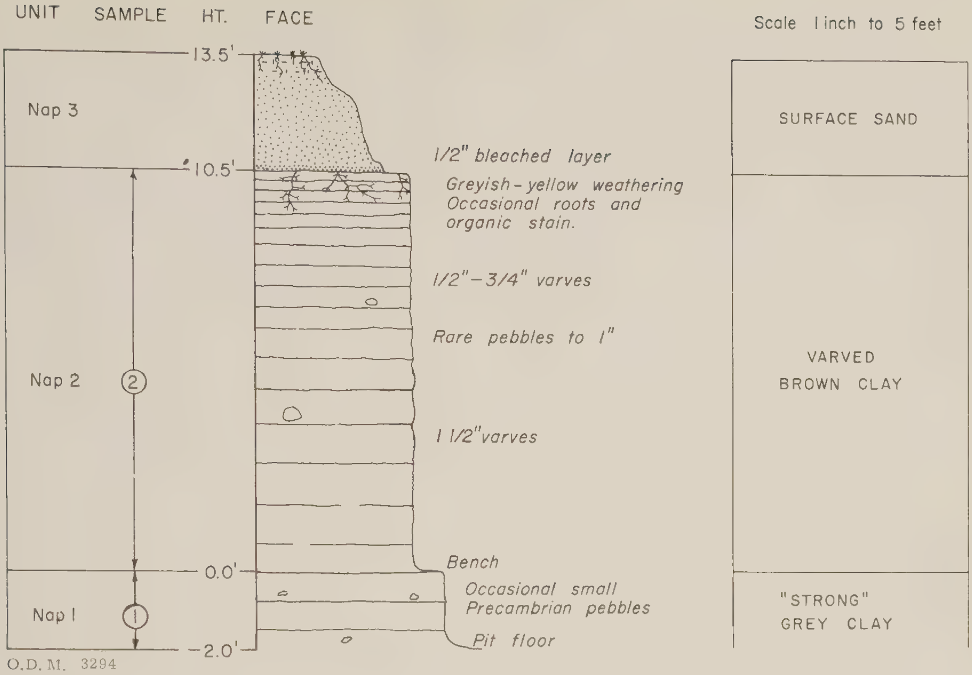
GEOLOGY

The upper 2–4 feet of a limy till common throughout southwestern Ontario was sifted and partly re-sorted during a lengthy inundation by the waters of glacial lakes Whittlesey and Warren. The McFarlane clay pit lies near the ancient shoreline of these lakes, and the sorting action is not as complete as in parts of Essex and Kent counties to the south. A moderate number of subangular pebbles, commonly less than ½-inch in size, are disseminated throughout the upper four feet and are noticeably abundant below. Light-coloured limestone pebbles are common, but rounded boulders of a variety of rock types also occur. The clay is mottled in orange-brown and grey-green. It is smooth, massive, and rather tough; fine roots are fairly common. The top six inches consist of black, crumbly, clay loam.

A number of small pits are scattered over a wide area north of the plant. At the time of the writer's visit in 1961 clay was being taken from a pit 75 by 15 feet with a 4-foot face. The results of chemical, mineralogical, and ceramic testing of a 4-foot vertical channel sample are given in tables 176, 177, 178.

NAPANEE BRICK AND TILE WORKS LIMITED

R. L. Chapman is the manager of a plant on the south bank of the Napanee River a mile southwest of Napanee. It has been owned by the Chapman family since 1917, but was built in 1869. The plant is located in lot 13, concession VI, North Fredericksburgh township, Lennox and Addington county.


UNIT
SAMPLE
HT.
FACE
Scale 1 inch to 5 feet
13.5'
Nap 3
10.5'
1/2" bleached layer
Greyish-yellow weathering
Occasional roots and
organic stain.
1/2"-3/4" varves
Rare pebbles to 1"
Nap 2
2
1 1/2" varves
0.0'
Bench
Occasional small
Precambrian pebbles
Nap 1
1
-2.0'
Pit floor
O.D.M. 3294
SURFACE SAND
VARVED
BROWN CLAY
"STRONG"
GREY CLAY

Unit		Thickness (*feet*)
NAP 3	SAND: Orange-brown, medium-grained; thin bleached layer at base; loamy topsoil and sod at surface.	3.0
NAP 2	CLAY: Medium olive-brown, drying buff-yellow; silty; varved in layers progressively thinning from 2 inches at the bottom to ¼-inch at top; rare rounded pebbles to 1-inch; minor rusty mottlings.	10.5
NAP 1	CLAY: Medium grey, drying pale grey; smooth, very plastic; coarsely varved; small (less than ¼-inch) pebbles of Precambrian rock are fairly common.	2+

Figure 42—Napanee Brick and Tile Works Ltd., pit section.

TABLE 179 Chemical Analyses:
Napanee Brick and Tile Works Limited

Sample	1	2	Composite
Height above floor (*feet*)	−2.0 to 0.0	0.0 to 10.5	−2.0 to 10.5
	(*percent*)	(*percent*)	(*percent*)
SiO_2			50.59
Al_2O_3			12.2
Fe_2O_3	6.80	5.98	5.11
CaO	6.11	9.80	8.63
MgO			4.87
Na_2O			1.80
K_2O			3.19
TiO_2			0.67
CO_2			7.48
H_2O+			1.61
H_2O-			1.67
SO_3			0.23
TOTAL			98.1
Loss on ignition	7.34	10.58	11.33
Soluble salts	0.86	0.89	

TABLE 180 Mineral Analyses:
Napanee Brick and Tile Works Limited
(A = abundant; B = moderate; C = minor;
ND = not detected)

Sample	1	2	Composite
Height above floor (*feet*)	−2.0 to 0.0	0.0 to 10.5	−2.0 to 10.5
	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals			
Quartz	18	18	18
Calcite	3	5	6
Dolomite	3	7	7
Soda-lime feldspar	7	4	6
Potash feldspar	<0.5	1	1
Amphibole	0.5–5	0.5–5	0.5–5
Gypsum	trace		
Clay minerals			
Illite	A	A	A
Chlorite	B	A	C
Expanding minerals	C	ND	B*

*Montmorillonite.

Table 181 Ceramic Tests:
Napanee Brick and Tile Works Limited

sample 1: −2.0′ to 0.0′

Water of plasticity (*percent*)	37
Lineal drying shrinkage (*percent*)	7.9
Pyrometric cone equivalent	2

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	1.1	7.6
Colour	pale salmon	pale salmon	red-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	19.9	19.0	0.17
5-hour boil absorption (%)	20.6	19.1	0.25
Specific gravity	1.71	1.75	2.46

remarks: Briquettes are slightly overfired and marked by a moderate yellow scum at cone 03.

sample 2: 0.0′–10.5′

Water of plasticity (*percent*)	28
Lineal drying shrinkage (*percent*)	5.6
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 1980°F))
Lineal firing shrinkage (%)	0.4	0.5	4.5
Colour	pale salmon	pale salmon	red-brown
Hardness	moderately hard	almost hard	very hard
24-hour absorption (%)	19.5	18.7	9.7
5-hour boil absorption (%)	20.5	20.0	12.9
Specific gravity	1.69	1.70	1.93

remarks: Yellow scum is severe on briquettes fired to cone 03.

Early descriptions are given by Baker (1906, p. 77) and Montgomery (1930, pp. 134–135).

Plant

Eighteen men are employed during the 9-month working season. Annual production runs to 2½ million drain tile and a small number of soft-mud brick.

Clay is worked-over, mixed, and allowed to partially dry on the pit floor before hauling to the plant. A 1-yard Michigan front-end loader reclaims the clay from the pit, carries it 500 feet to the plant, and dumps it in a 30 by 50-foot enclosed storage area. Clay is fed to an 18-inch Parkhill rolls disintegrator which effectively kicks-out the occasional large pebble and grinds the smaller ones. A box-proportioning feeder manufactured by the German firm of Karl Handle and Son delivers the clay to a large 42-inch diameter, 21-inch, Handle smooth rolls. The rolls are in tight contact and are individually driven by 50 and 30 h.p. electric motors. Any pebbles present in the feed are reduced to minus 1/16-inch. The clay is fed by belt to an F-R-H Plymouth Special auger machine operated at a rate of 1,600 tile per hour. Tile are extruded in a single stream under 15 inches of vacuum. They are cut by a Bensing Automatic cutter and hacked 250 to a car.

An 18-track room dryer using waste heat has a capacity of 60,000 tile. Drying time is three days at 130°F. A further drying capacity of 60,000 tile is available in open-air sheds for summer use. Four beehive kilns, with diameters of 30 feet, hold 25,000 tile each. They are gas-fired to a temperature of 1800°F and are on-fire for a total of 48 hours. The turnover cycle is about seven days.

Several kilns of soft-mud brick are produced each season. Clay is diverted to the soft-mud circuit from a transfer point after the grinding section. Feed to either the stiff-mud or soft-mud circuits is regulated from a control panel. In the making of soft-mud brick considerable water is added to the clay in a single-shaft horizontal pug mill immediately ahead of the brick-forming equipment. Clay is fed from an elevated vertical pugging section to the Parkhill Martin-A-Brick machine. Brick are formed in water-soaked wood moulds in the usual way. The moulds contain five bricks each. They are thoroughly sanded after each use. Brick are carried to the drying racks on small wood pallets.

GEOLOGY

Glacial Lake Iroquois occupied the Lake Ontario basin towards the close of the Wisconsinan stage of the Pleistocene epoch, when the retreating Ontario lobe formed an ice-dam across the Thousand Islands region. The waters of Lake Iroquois stood more than 100 feet above the present level of Lake Ontario, so that deposits of varved clay are not uncommon in an area extending 15–20 miles north of the present shore between Trenton and Kingston. In 1936 A. P. Coleman (1937, p. 34) reported that "18 feet of varved clay can be seen, the lower part well stratified, the upper less evidently so," resting on sand and gravel, in the pit of the Napanee Brick and Tile Works. In the present pit 10 feet of varved clay, oxidized to a medium olive-brown colour, overlie grey varved clay. About 10 percent of grey clay is batched with brown clay for most tile sizes, but the proportion of grey clay is increased in the larger tile. Three feet of medium-grained brown sand is stripped from the top of the clay bank.

The pit is irregular in shape, about 400 by 200 feet, and opens onto the Napanee River at water level. The face of the pit is illustrated in figure 42 and described in the following notes. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 179, 180, 181.

NATIONAL SEWER PIPE LIMITED

National Sewer Pipe Limited operates two plants: one on the lakeshore at Clarkson, the other at 330 Wentworth Street, North, in Hamilton. The company is a consolidation of the Hamilton and Toronto Sewer Pipe Company Limited, the Ontario Sewer Pipe and Clay Products Limited, and the Dominion Sewer Pipe and Clay Industries Limited. The merger took place in 1929, at which time there were four plants operating at Hamilton, Aldershot, Swansea, and Mimico. Latterly only the Hamilton and Swansea plants were operated, and in 1957 a new plant in Clarkson replaced the Swansea operation. Early descriptions of the sewer pipe industry are given by Baker (1906, pp. 116–118) and Montgomery (1930, pp. 168–170).

The Clarkson Plant

The plant produces 45,000 tons of finished ware annually. Sewer pipe is made in sizes ranging from 4 to 27 inches in diameter, in lengths of 3½, 4, and 5 feet. Flue linings are produced in 8½-inch by 8½-inch and 8½-inch by 13-inch sizes. About 110 men are employed on a continuous basis.

Two D4 Caterpillar tractors, one equipped with a 1½-yard front-end bucket, scrape the red Aldershot clay into piles and load trucks for the haul from the pit at Aldershot; two dump trucks haul 25 tons each to the Clarkson plant. Fireclay and shale are imported from Pennsylvania and arrive at the plant by truck and boat. All clays are received at the crusher building and move from a hopper through the 48-inch by 48-inch Eagle Model C Senior double-roll crusher. The minus 3-inch lump is distributed by shuttle conveyor travelling lengthwise beneath the roof of the 325-foot by 80-foot storage building. Storage capacity for raw clay is 20,000 tons. The clays and shale are batched by a Hough Payloader in the proportion of 55 percent Aldershot red, 30 percent fireclay, and 15 percent Pennsylvania shale. The feed is conveyed from the hoppers by two apron conveyors, each feeding a 9-foot Bonnot drypan. The Apron conveyors ahead of each pan are automatically controlled by the electrical resistance on each of the 50-h.p. drive-motors. Two electrically heated Tyler single-deck vibrating screens, 4 feet by 10 feet, remove the minus 12 mesh and return the oversize to the pans. A double-deck 4-foot by 8-foot screen sizes grog that is ground in a separate circuit. Ground clay is stored in two 100-ton bins.

Clay is distributed by belt conveyors to feed hoppers ahead of the six clay presses. Each line operates independently as follows:

Press No. 1. Clay is fed from the hopper to a 24-inch by 10-foot pug mill; thence to a second pug mill, 24-inch by 12 feet, and then to the top of the mud cylinder of the Pearne and Lacy Vertical hydraulic press. The press is equipped with two hydraulic pumps each driven by a 75 h.p. motor. The larger sizes of pipe, from 12 to 27 inches in diameter, 5 feet long, are produced. A Pearne and Lacy Junior Octopus automatically trims and handles the pipe from the press to the lift truck off-bearing station.

Press No. 2. From the hopper clay is fed to an F-R-H Junior combined pug and auger machine for the production of 6, 8, 9 and 10-inch bell-and-spigot pipe 3½ feet long, and similar-sized plain end pipe 4 feet long. The pipe are automatically trimmed and turned up on dryer pallets.

Press No. 3. A Bonnot Challenger pug and auger machine extrudes flue lining in the conventional way. They are cut by an F-R-H Type 2BT automatic cutter.

Press No. 4. A Bradley and Craven 13-inch combined pug and vertical auger press is equipped with special dies for the production of curves, elbows, traps, and junction pieces in diameters from 4 to 10 inches.

Press No. 5. Small plain end pipe are extruded by an F-R-H Hummer type 7 pug mill and auger machine. Pipe are automatically cut into 4-foot lengths, trimmed and placed horizontally onto drying racks.

Press No. 6. Same as press no. 4.

All ware are hacked on dryer racks or pallets and moved to the dryers by Clark forklift trucks. There are 14 batch-type waste-heat room dryers, each measuring 88 feet long by 13 feet wide and 17 feet high, and each having a capacity of 50 tons. Ware

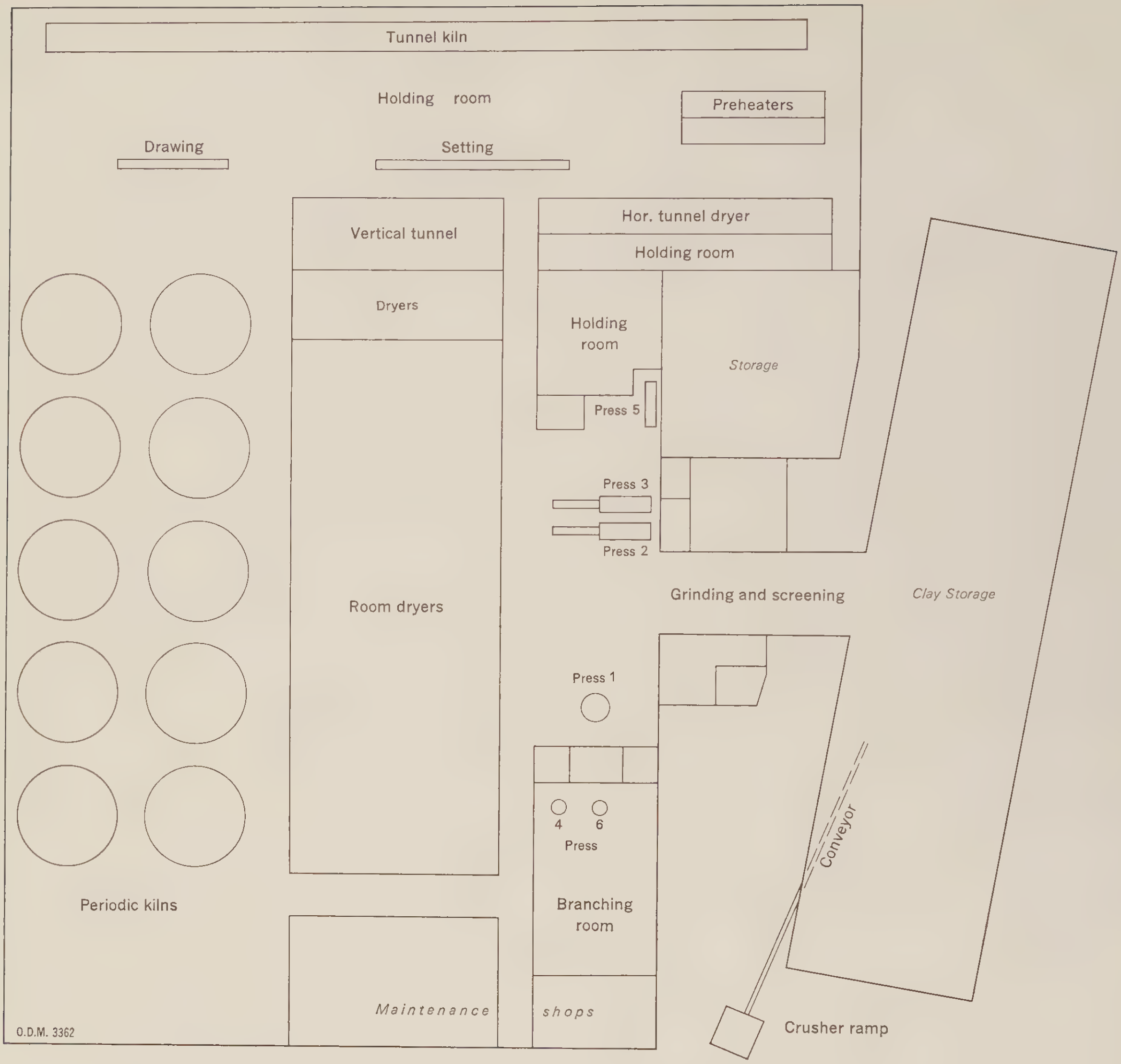

Tunnel kiln
Holding room
Preheaters
Drawing
Setting
Vertical tunnel
Dryers
Hor. tunnel dryer
Holding room
Holding room
Storage
Press 5
Press 3
Press 2
Room dryers
Grinding and screening
Clay Storage
Press 1
4
6
Press
Conveyor
Branching room
Periodic kilns
Maintenance
shops
Crusher ramp
O.D.M. 3362

Figure 43–National Sewer Pipe Ltd., Clarkson plant, 1963.

are dried at 200°F for one to five days depending on the size of individual pieces. There are three tunnel dryers that carry palletized ware on roller conveyors. Two of them measure 88 feet long by 28 feet wide by 14.5 feet high and hold about 75 tons each. Waste heat is circulated vertically in these dryers, passing from top to bottom through the vertically palletized pipe. Pipe of 4- to 6-inch diameter are racked horizontally in the third tunnel dryer. It measures 119 feet long by 13 feet wide by 10 feet high. Waste heat is forced horizontally through the ware. Drying time in the tunnels is normally 16 to 48 hours.

There are 10 periodic kilns and one tunnel kiln. Smaller-sized ware, generally less than 9 inches in diameter, are fired in the 324-foot tunnel. A 2-track 60-foot preheater raises the temperature of the ware to 350°F before it enters the tunnel. Maximum firing temperature is 1870°F and time in the kiln is 44 hours. Either gas or oil is used. Productive capacity of the tunnel is 70 tons per day. The 10 periodics are 38-foot beehive downdraft kilns. They are used primarily for the larger sizes of pipe. Either oil or natural gas is used to fire the kilns to 1870°F. They are kept on fire for 2 to 5 days, depending on

Photo 46—National Sewer Pipe Limited; Clarkson plant 1961.
(Photo by Charles Osland, Oakville.)

the size of the ware, and are backdrafted to control the cooling cycle. Each kiln has a capacity of about 65 tons of ware.

Finished ware are stored in the yard and shipped by truck or rail.

The Hamilton Plant

The Hamilton plant, formerly also a producer of sewer pipe and flue lining, was converted in 1963 to the manufacture of buff brick, glazed brick and ceramic glazed structural facing tile. The clay used is imported from Western Pennsylvania and is generally brought in by rail and lake carrier. Other raw materials for glazing etc. are obtained from various sources.

Raw clay is stored in a building of 12,000–15,000 tons capacity and is recovered by a rubber-tired front-end loader. The clay is dumped into hoppers which are mounted over apron feeders. One feeder feeds clay to a model 418 American rim-discharge grinder; the other feeds a 9-foot Raymond drypan. The material is elevated and screened on two electrically-heated 4-foot by 8-foot Tyler vibrating screens. The ground product (generally minus-20 mesh) is stored in two 60-ton storage bins.

Ground clay is recovered by screw feeders and carried by belt conveyors to surge bins ahead of the two extrusion machines.

Machine No. 1. Clay and water is fed into a 404A American combined pug mill and auger machine for the production of brick. The brick are extruded, cut to length by a Chambers model 32L cutter, and then pass through spray booths onto an off-bearing conveyor. The brick are spray-glazed on the wet column as they pass through the booths, and are then hacked in cubes of approximately 400 brick, two cubes to a dryer car.

Machine No. 2. Clay and water are fed into an F-R-H Junior combined pug and auger machine for the production of tile (or brick). The tile are extruded, cut to length by a Chambers model 32L cutter, and conveyed along an off-bearing conveyor;

the tile are hacked onto dryer cars. After drying, the tile are transported to glazing booths.

Machine No. 3. This is a 25-ton Denison hydraulic press for the production of special shapes required in tile. Stiff-mud blanks are made on one of the extrusion machines and these are pressed to the required shape in suitable dies on the hydraulic press.

There are two 8-track continuous dryers for drying brick and tile. The dryers are approximately 32 feet wide by 65 feet long. Heat is supplied from the cooling end of the tunnel kilns, supplemented by electric duct heaters. Air is recirculated vertically in these dryers, and cars are pushed through the dryer on a regular schedule. Dried brick go directly to the setting area for cube-setting on kiln cars. Dried tile are unloaded from dryer cars onto a tile-glazing conveyor line. The tile pass through two spray booths where glaze is applied, then set directly from the conveyor onto kiln cars.

Glaze materials are stored on the second floor and raw batches are weighed into a portable bin. The batch is then dumped into a porcelain-lined ball mill and the glaze is wet milled as required. Milled glaze is stored in stainless or plastic-lined tanks until ready for use. The glaze is pumped and screened into 60 gal. pressure tanks for use at the various spray booths.

There are two Allied tunnel kilns for firing the glazed brick and tile. The kilns are 310 feet long. Peak firing temperature is 2,000°F, and firing time is 80 hours. The preheat section is heated by natural gas, and the main firing section is heated by light oil.

Brick cubes are unloaded from kiln cars and taken to an inspection and packaging area. Glazed brick are inspected, and acceptable brick are placed in partitioned cardboard trays. Trays of 6 brick each are then cubed in 500 packs or stacked on pallets.

Tile are unloaded from kiln cars; acceptable tile are sent through a grinder for sizing. After sizing and final inspection each tile is covered with a cardboard lid (glazed face and edges are completely protected) and the packaged tile are loaded onto pallets and strapped.

Practically all finished brick and tile are shipped in cubes, or on pallets, by truck.

GEOLOGY

The best quality surface clay, and the only one suitable for sewer pipe in southern Ontario, is the Aldershot red clay. Clay of this type was derived from the Queenston shale that formed the shoreline

TABLE 182 Chemical Analysis: National Sewer Pipe Limited

Sample	1
Height above floor (*feet*)	bulk
	(*percent*)
SiO_2	62.70
Al_2O_3	15.2
Fe_2O_3	6.73
CaO	1.43
MgO	2.47
Na_2O	0.71
K_2O	3.60
TiO_2	0.92
CO_2	0.72
H_2O+	3.32
H_2O-	1.83
SO_3	0.18
TOTAL	99.8
Loss on ignition	6.68

TABLE 183 Mineral Analysis: National Sewer Pipe Limited
(A = abundant; B = moderate; C = minor; ND = not detected)

Sample	1
Height above floor (*feet*)	bulk
	(*percent*)
Non-clay minerals	
Quartz	36
Calcite	ND
Dolomite	ND
Soda-lime feldspar	7
Potash feldspar	1
Clay minerals	
Illite	A
Chlorite	B
Expanding minerals	C*

*Vermiculite.

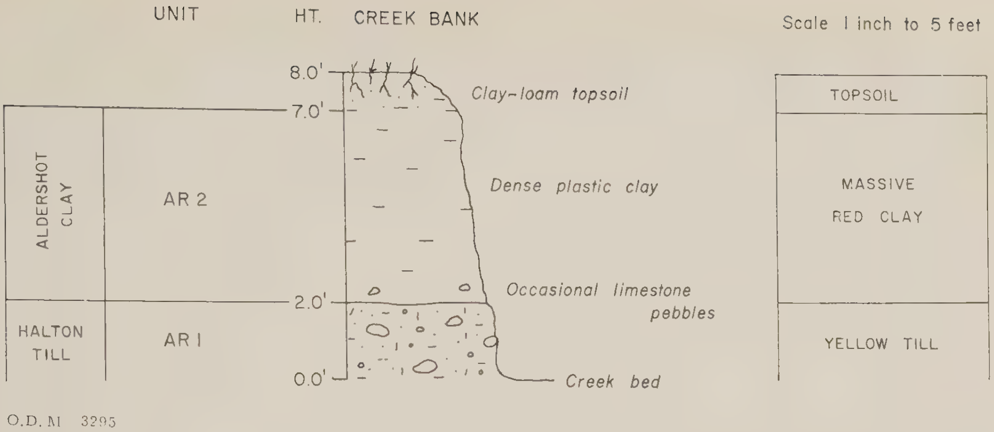
TABLE 184 Ceramic Tests: National Sewer Pipe Ltd.

SAMPLE 1: bulk

Water of plasticity (*percent*)	26
Lineal drying shrinkage (*percent*)	5.5
Pyrometric cone equivalent	7–8

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	4.6	8.3
Colour	salmon	red	dark red
Hardness	moderately soft	very hard	very hard
24-hour absorption (%)	13.6	7.3	0.07
5-hour boil absorption (%)	14.6	8.9	0.14
Specific gravity	1.86	2.09	2.36

REMARKS: Briquettes are overfired but undeformed at cone 03.


UNIT
HT.
CREEK BANK
Scale 1 inch to 5 feet
8.0'
7.0'
2.0'
0.0'
ALDERSHOT CLAY
AR 2
HALTON TILL
AR 1
Clay-loam topsoil
Dense plastic clay
Occasional limestone pebbles
Creek bed
TOPSOIL
MASSIVE RED CLAY
YELLOW TILL
O.D.M 3295

Unit		Thickness (*feet*)
	Overburden: Surface soil and sod.	1.0
AR 2	**Clay:** Red-brown, drying brown; smooth, dense, plastic; massive; stoneless except for occasional rounded limestone pebbles in the bottom 6 inches.	5.0
AR 1	**Till:** Olive-grey, drying buff-yellow; silty, plastic, massive; moderate content of subrounded shale and limestone pebbles to 4 inches in size.	2+

Figure 44–National Sewer Pipe Ltd., pit section.

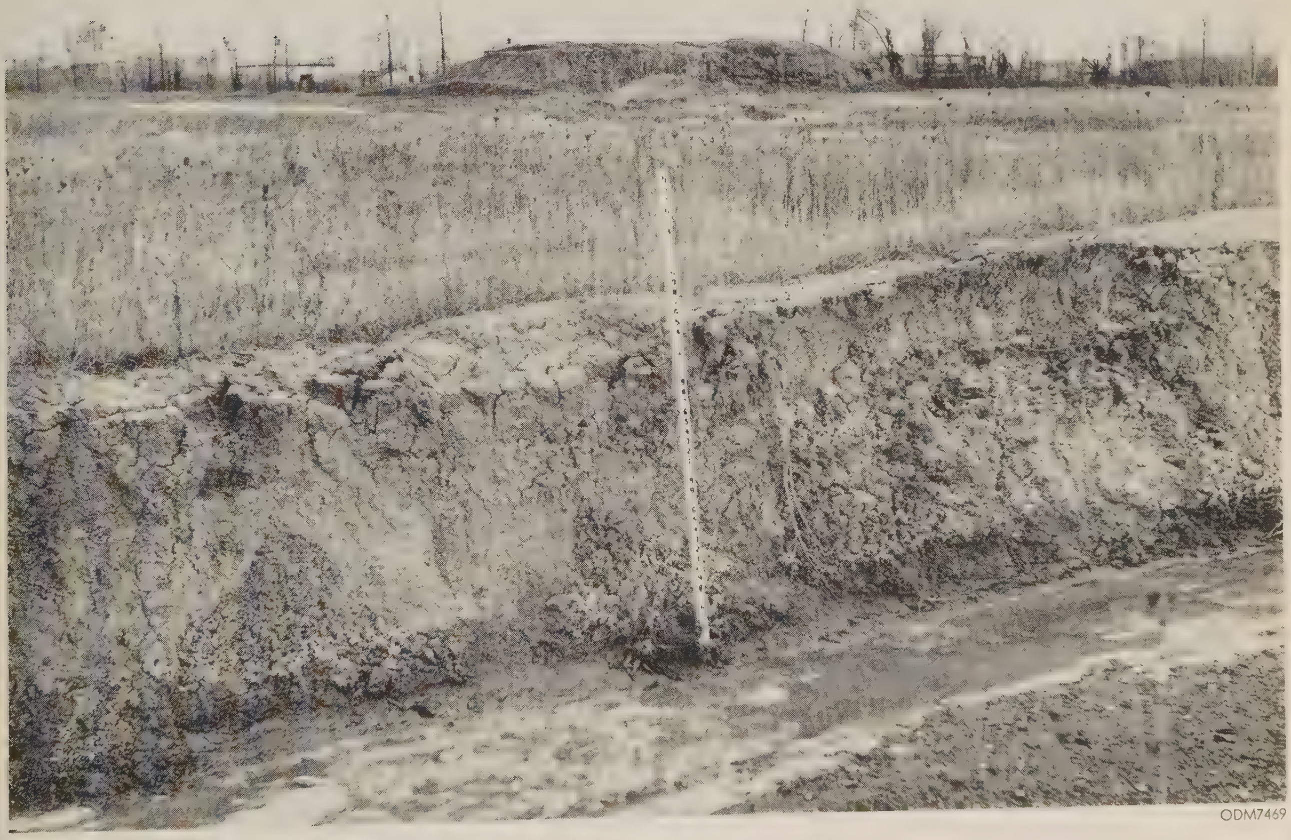

ODM7469

Photo 47–Aldershot red clay; pit and stockpile of National Sewer Pipe Limited, 1965.

of Lake Iroquois 12,000 years ago (Karrow 1963, p. 56). It was deposited in quiet lagoonal waters separated from Lake Iroquois by the Aldershot Bar, a beach deposit of sand and gravel that extends from the mouth of Cootes Paradise eastward almost to King Road. Similar clay was also laid down behind the Hamilton Bar, a gravel ridge that overlaps the Aldershot Bar at Cootes Paradise and extends southward through the west end of Hamilton. The clay was formerly used extensively in the manufacture of brick, structural and drain tile, sewer pipe, flower pots, and art pottery. Urban construction and zoning regulations have effectively withdrawn any red clay remaining in the Hamilton deposit from industrial use. The recently completed Hamilton by-pass, highway no. 403, covers most of the remaining clay in the eastern end of the Aldershot deposit, while that towards the west has already been removed for brick and tile.

Thickness of the red clay in the Hamilton deposit was typically 6–7 feet (Coleman 1937, p. 6); somewhat less in the Aldershot deposit. The deposit thins rapidly east of the Aldershot Bar, and becomes silty and lighter coloured as a result of contamination from materials derived from a till terrace that formed the old shoreline east of the shale outcrops. National Sewer Pipe Limited recovers red clay on the west side of King Road along, and immediately south of, highway no. 403. After stripping a few inches of topsoil and grass, the red clay is bulldozed into piles for subsequent loading and trucking to the Clarkson and Hamilton plants. Thickness of clay at this point is rarely more than 3 feet and commonly is about 1 foot. However, a section exposed in a creek bank several hundred feet west of the clay workings consists of 5 feet of red clay. This section is illustrated in figure 44 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of a bulk sample of the clay in one of the small stockpiles awaiting shipment to the plant are given in tables 182, 183, 184.

Similarity of the red Aldershot clay to the parent Queenston shale can be seen by comparing the chemical and mineral analyses of the clay with that of the typical shale. The leaching that attended the erosion and re-deposition of the shale fragments all but removed the carbonate minerals. The low lime content of the clay is largely responsible for its superior ceramic qualities.

A more complete study of the Aldershot clay area is contained in a later volume.

NEW LISKEARD TILE YARD

A new plant located in Dymond township, District of Timiskaming, 2½ miles due west of New Liskeard, was nearing completion in August 1965. V. G. Shepherdson is the owner. Baker (1906, pp. 83–84) mentions two plants formerly located at New Liskeard.

Plant

The plant is of wood frame construction with galvanized roofing and siding. Drain tile will be the major product, but some brick may also be made. The working force is expected to be eight.

Clay will be taken principally from the valley of the south branch of Wabi Creek, 500 feet east of the plant. A large open-air stockpile and a small covered stockpile will be maintained at the plant. The clay will be reclaimed by a ½-yard Hough front-end loader and dumped directly to a single-shaft Parkhill pug feeder. A 20-inch belt conveyor discharges to a disintegrator equipped with rolls 16 and 24 inches in diameter. A pair of 30-inch diameter smooth rolls are located immediately beneath the disintegrator. Discharge from the rolls is carried by a short screw conveyor to an 18-inch belt, where sand will be added as required to modify the highly plastic clay. Tempering water will be added to the batch in a single-shaft Parkhill pug mill that discharges directly to a large Bonnot combined pug de-airing, and auger machine. The Bonnot machine is driven by a Waukesha gas-burning stationary engine of 145 hp. The extruded tile stream will be cut by a modified Bensing's cutter. The tile will be hacked on 3-tier racks for drying.

It is planned to use natural drying in a covered storage area initially, but waste heat from the kiln will ultimately be used. The drying racks will be moved by rack-lift trucks. A single shed-covered beehive kiln with an inside diameter of 31 feet will hold about 30,000 tile. The ten fireboxes burn natural gas.

GEOLOGY

Drilling has proven 85 feet of predominantly buff-burning varved clay below the plant site. The clay was deposited from glacial Lake Barlow that was formed in the Timiskaming basin when the glacier had retreated into northern Ontario. Mr. Shepherdson also has a source of red-burning clay about 2 miles distant from the plant.

ODM7470

Photo 48–New Liskeard Tile Yard; plant 1965.

TABLE 185 Chemical Analyses: New Liskeard Clay

	Lower Blue Clay	Upper Brown Clay
	(percent)	*(percent)*
SiO_2	49.68	58.30
Al_2O_3	13.95	15.70
Fe_2O_3	5.32	5.41
CaO	9.46	5.10
MgO	4.16	3.27
Na_2O	1.96	2.04
K_2O	2.76	2.73
SO_3	0.04	0.04
Loss on ignition	1.29*	7.30
	88.62	99.89

*This figure is probably in error by a factor of 10.

Baker (1906, p. 26) gives analyses for similar clay used by the two former brickyards in New Liskeard. One is a highly plastic blue clay occurring below a somewhat leached and oxidized brown clay. The two analyses are reproduced in Table 185.

NORWICH BRICK AND TILE LIMITED

This plant is about 90 years old. It was owned by the Deller family for about 70 years and was transferred to the present owners, Fred and Jack McKie, in March 1964. It is located about 2 miles northwest of Norwich in lot 11, concession III, North Norwich township, Oxford county. Early descriptions are given by Baker (1906, p. 86) and Montgomery (1930, p. 144).

Plant

Production is 1,300,000 drain tile annually, in sizes from 4 to 12 inches in diameter. Fourteen men are employed during the 7-month working season.

A TD9 International bulldozer is used for stripping sod and minor stones from the top of the clay deposit. Clay is taken from the bank by a ½-yard Insley gasoline backhoe and loaded on a truck for the 1,000-foot haul to the plant. It is fed manually from the ramp into a Parkhill single-shaft pug feeder. A 22-inch double conical rolls crusher, with smooth closely-set faces and differential rolls speed, is fed by a belt conveyor; it discharges directly to a Parkhill single-shaft pug mill. A Brewer auger machine extrudes tile at the rate of 1,250 per hour without de-airing. The tile are cut by an F-R-H cutter and are transported by wheelbarrow to the drying racks.

There are 9 open-air shed dryers measuring 120 by 22 feet each and having a total drying capacity of 90,000 tile. Average drying time is seven to ten days. Four beehive kilns with diameters of 26 feet hold

ODM7471

Photo 49—Norwich Brick and Tile Limited; clay pit 1965.

22,000 tile each. They are fired by soft coal to a peak temperature of 1850°–1900°F, and are on-fire for five days. Turnover cycle is about eleven days.

GEOLOGY

Stratified deposits of clay and silt laid down beneath the waters of glacial lakes Whittlesey and Warren are found a considerable distance north of the present Lake Erie shoreline. At Norwich, stratified lake clays occupy the valleys between ridges of brown silty till. The pit of Norwich Brick and Tile Limited is located in the valley of Otter Creek, two miles northwest of the village. The pit is irregular in shape and averages 7–8 feet deep. The stoneless clays grade downwards into a grey silty till, and excavation is carried to the top of the stony zone. A 10-foot section being worked in 1961 is illustrated in figure 45 and described in the following notes. The results of chemical mineralogical, and ceramic testing of a 10.5-foot vertical channel sample are given in tables 186, 187, 188.

TABLE 186 Partial Chemical Analysis: Norwich Brick & Tile Limited

Sample	1
Height above floor (*feet*)	0.0–10.5
	(*percent*)
Fe_2O_3	5.00
CaO	15.8
Loss on ignition	17.52
Soluble salts	0.83

TABLE 187 Mineral Analysis: Norwich Brick & Tile Limited
B = moderate; C = minor)

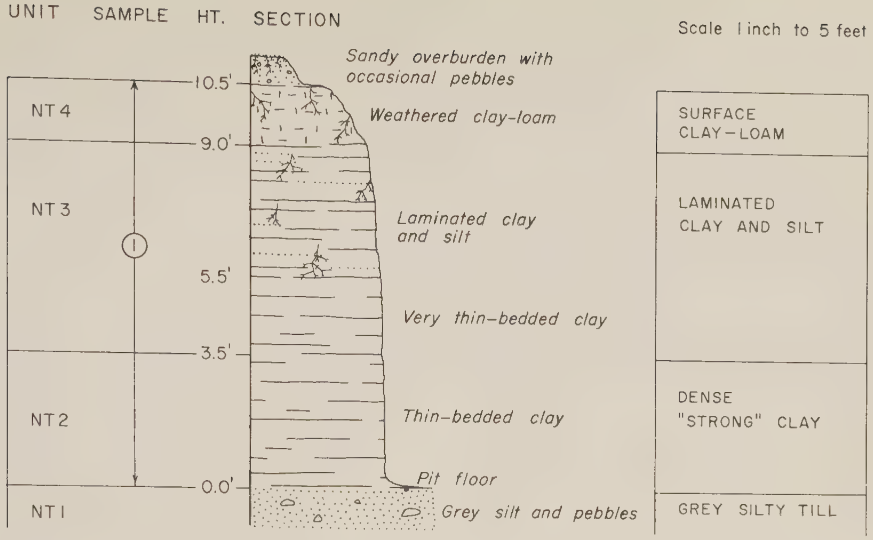
Sample	1
Height above floor (*feet*)	0.0–10.5
	(*percent*)
Non-clay minerals	
Quartz	22
Calcite	21
Dolomite	7
Soda-lime feldspar	3
Potash feldspar	1
Amphibole	<1
Clay minerals	
Illite	B
Chlorite	B
Expanding minerals	C

TABLE 188 Ceramic Tests: Norwich Brick & Tile Ltd.

SAMPLE 1: 0.0′–10.5′

Water of plasticity (*percent*)	24
Lineal drying shrinkage (*percent*)	5.2
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.7	1.8	2.3
Colour	tan	cream-tan	cream-buff
Hardness	soft	soft	almost hard
24-hour absorption (%)	18.7	18.4	17.6
5-hour boil absorption (%)	19.8	19.4	19.6
Specific gravity	1.74	1.74	1.75



O. D.M. 3296

Unit		Thickness (*feet*)
NT 4	CLAY: Brown to black, drying buff-yellow; massive, loamy, stoneless; fine roots common.	1.5
NT 3	CLAY: Olive-grey, drying pale grey; smooth, plastic, stoneless; stratified in layers $\frac{1}{8}$–$\frac{1}{2}$ inches thick at top, $\frac{1}{4}$–1 inch thick towards bottom; stratification marked by a sprinkling of yellow silt; silt layers become thicker towards top; a few fine roots; blue irridescent stain on fractures.	5.5
NT 2	CLAY: Olive-grey, drying pale grey; smooth, soft, plastic, stoneless; stratification barely discernible in layers 1–4 inches thick; minor rusty alteration along occasional root channels.	3.5
NT 1	TILL: Grey, drying pale grey; very silty; occasional limestone pebbles.	2+

Figure 45–Norwich Brick and Tile Limited, pit section.

PAISLEY BRICK AND TILE YARD

The Paisley Brick and Tile Yard is located on the eastern limits of Paisley. The plant was purchased by J. M. Seiler in 1948; it had been owned by the Winch family almost continuously since 1860. The plant is on the north side of the Saugeen River in lot 4, concession V, Elderslie township, Bruce county. Early descriptions are given by Baker (1906, p. 59) and Montgomery (1930, p. 110). Clay at Paisley is well described by Keele (1924, p. 89).

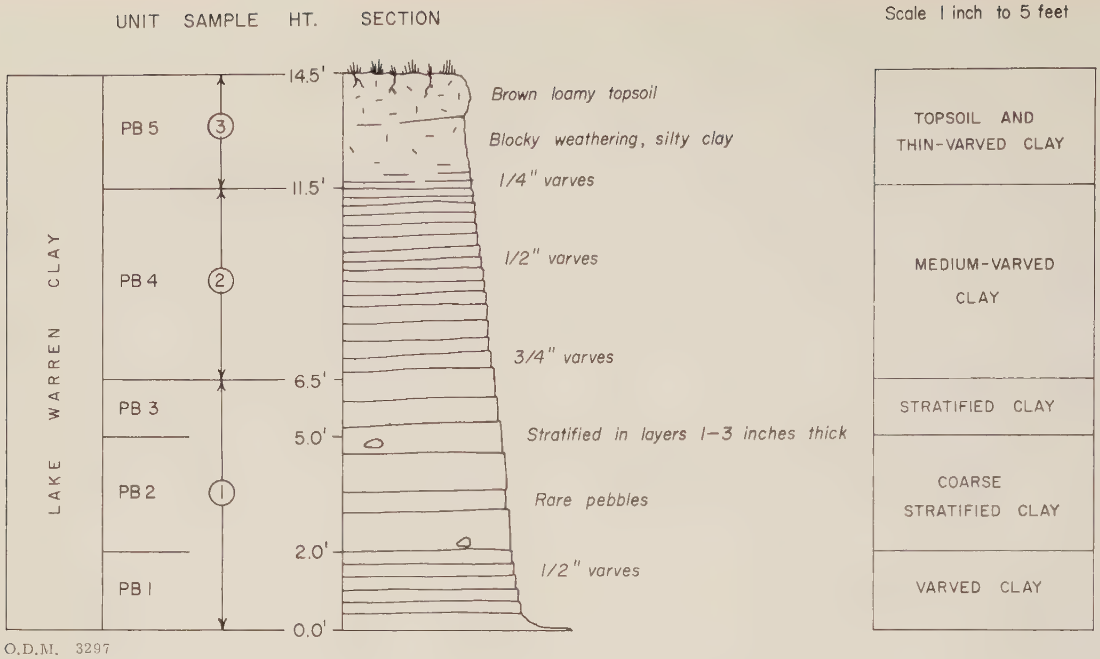
Plant

The plant operates nine months of the year with fourteen employees. About 1¼ million drain tile are produced annually in sizes ranging from four to fourteen inches in diameter. Brick are no longer made.

Clay is taken from the bank by an International No. 9 front-end loader of 1½-yard capacity. Three six-yard trucks are available for the 500-foot haul to the plant. Shed storage for 1,000 tons is available. Clay is taken from the stockpile, or dumped directly from the truck, to a single-shaft pug feeder. A 24-inch Parkhill smooth rolls crusher, consisting of one small-diameter high-speed roll and one large slow-speed roll, precedes a Parkhill single-shaft pug mill. Tempering water is added at the pug mill as required. Clay is delivered by 12-inch belt to an American Clay Machinery auger extruder. Tile are extruded in a single stream at the rate of 1,500 per per hour. There is no de-airing. An F-R-H automatic cutter is used. Tile are hacked in three tiers, 230 to a rack, and are moved to the dryers by gasoline-powered rack-lift trucks. A 120 h.p. Caterpillar diesel unit provides electrical power for all equipment.

Two waste-heat room dryers have a total capacity of 40,000 tile. Drying time is three days. Temperature is gradually increased from 90°F at the start to 250°F at the finish. Some air-drying is done outside during favourable weather. Two beehive kilns with diameters of 22 feet hold 18,000 tile each; one 30-foot iron-clad kiln holds 30,000 tile. They are oil-fired and are operated on a cycle of eight to ten days.

Tile are made at the rate of 10,000 per day during the first four days of each week. With the drying capacity reached, the men spend the fifth day loading or unloading kilns, or performing general maintenance work.


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
LAKE WARREN CLAY
PB 5
PB 4
PB 3
PB 2
PB 1
③
②
①
14.5'
11.5'
6.5'
5.0'
2.0'
0.0'
Brown loamy topsoil
Blocky weathering, silty clay
1/4" varves
1/2" varves
3/4" varves
Stratified in layers 1–3 inches thick
Rare pebbles
1/2" varves
TOPSOIL AND THIN-VARVED CLAY
MEDIUM-VARVED CLAY
STRATIFIED CLAY
COARSE STRATIFIED CLAY
VARVED CLAY
O.D.M. 3297

Unit		Thickness (*feet*)
PB 5	CLAY: Medium brown clay (25 percent) and light brown silt (75 percent), drying light brown; uniform ¼-inch varves grading upwards to a blocky, then loamy, topsoil.	3.0
PB 4	CLAY: Red brown clay (25 percent) and light brown silt (75 percent), drying light brown; varved in layers ¾-inch thick at base grading upwards to ¼-inch at top; blocky, with grey-green staining on joints and fractures.	5.0
PB 3	CLAY: Red-brown clay and yellow-brown silt; stratified in 1-inch layers, each layer uniformly graded from clay at the top to silt at the base; blocky, with grey-green staining on joints and fractures.	1.5
PB 2	CLAY: Red-brown clay and yellow-brown silty clay; stratified in layers 1–3 inches thick, with finer colour and textural laminations superimposed; rare pebbles; blocky, with grey-green staining on joints and fractures.	3.0
PB 1	CLAY: Dark red-brown clay (70 percent), grey-brown clay (15 percent), and grey silt (15 percent); uniformly varved in layers ½-inch thick; all three components sharply defined within a single varve, and arranged from top to bottom in the order: red-brown clay, grey-grown clay, grey silt.	2.0

Figure 46–Paisley Brick and Tile Yard, pit section.

TABLE 189 Chemical Analyses: Paisley Brick and Tile Yard

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–6.5	6.5–11.5	11.5–14.5	4.5–14.5
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				40.73
Al_2O_3				12.3
Fe_2O_3	5.24	4.98	5.86	4.99
CaO	13.06	14.75	7.63	14.5
MgO				5.33
Na_2O				0.68
K_2O				3.61
TiO_2				0.59
CO_2				14.02
H_2O+				2.55
H_2O-				1.24
SO_3				0.17
TOTAL				100.6
Loss on ignition	17.90	18.91	13.97	18.22
Soluble salts	0.78	1.17	0.74	

TABLE 190 Mineral Analyses: Paisley Brick and Tile Yard (A = abundant; B = moderate; C = minor)

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–6.5	6.5–11.5	11.5–14.5	4.5–14.5
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	15	22	32	19
Calcite	13	14	7	16
Dolomite	9	9	8	11
Soda-lime feldspar	3	2	2	1
Potash feldspar	1	1	1	<0.5
Amphibole				<1
Clay minerals				
Illite	A	A	A	A
Chlorite	B	C	C	C
Expanding minerals			C	C

TABLE 191 Ceramic Tests: Paisley Brick & Tile Yard

SAMPLE 1: 0.0′–6.5′

Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	6.8
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	2.7	3.4	4.7
Colour	pink-tan	cream	buff
Hardness	hard	hard	very hard
24-hour absorption (%)	18.8	17.9	14.7
5-hour boil absorption (%)	19.5	18.8	16.0
Specific gravity	1.75	1.77	1.85

REMARKS: Requires careful drying to avoid cracking. Briquettes are smooth-textured and attractive at cones 06 and 03.

SAMPLE 2: 6.5′–11.5′

Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	7.1
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	2.1	2.9	3.2
Colour	pale salmon	cream	buff
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)	19.0	17.7	15.8
5-hour boil absorption (%)	19.4	18.5	18.9
Specific gravity	1.71	1.71	1.74

REMARKS: Smooth-textured attractive briquettes at all temperatures.

SAMPLE 3: 11.5′–14.5′

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	6.5
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5	0.5	3.0
Colour	salmon	salmon	pink-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	16.3	15.0	7.7
5-hour boil absorption (%)	17.2	16.1	8.3
Specific gravity	1.75	1.76	1.93

REMARKS: Briquettes have a streaked and mottled colouring.

COMPOSITE SAMPLE: 4.5′–14.5′

Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	5.6
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.7	2.1	4.1
Colour	pale salmon	pink-cream	yellow
Hardness	almost hard	hard	very hard
24-hour absorption (%)	19.1	18.2	7.8
5-hour boil absorption (%)	20.2	18.9	10.8
Specific gravity	1.71	1.73	1.94

REMARKS: Briquettes are almost overfired at cone 03.

GEOLOGY

Brown varved and stratified clays exposed in the deeply-cut banks of the Saugeen River between Paisley and Chesley are considered by Chapman and Putnam (1951, p. 190) to have been deposited in a bay of glacial Lake Warren. Although Lake Algonquin clays are also widespread across the Bruce Peninsula, the Paisley clays are found at an elevation greater than was ever reached by the waters of glacial Lake Algonquin.

The tile yard is one mile east of Paisley on the north bank of the Saugeen River. A new pit, established in 1961 on the brink of the steep north bank, exposed ten feet of varved clay. A complete chemical analysis, plus a mineral analysis and ceramic tests, was performed on a ten-foot vertical channel sample taken in 1961. In 1962 a fifteen-foot section of clay was exposed, and three vertical channel samples were taken. The section is illustrated in figure 46 and described in the following notes. The results of chemical, mineralogical, and ceramic testing are given in tables 189, 190, 191. In the tables of results, the 1961 sample is reported as a composite for the upper ten feet of the bank.

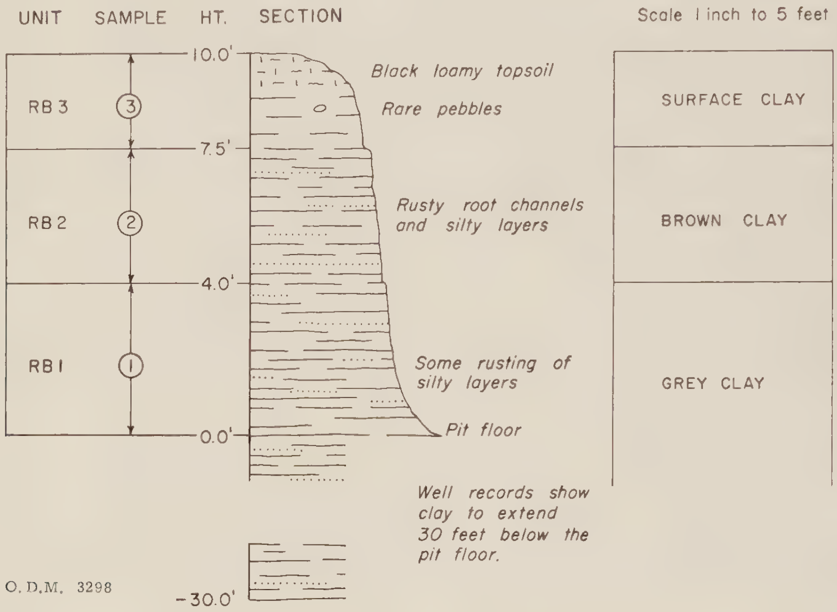
RYDALL BRICK AND TILE LIMITED

This plant is located at the junction of highways nos. 7 and 4, twelve miles north of London. J. A. Rydall purchased the plant in 1949; it had been owned by Chester McComb since 1923. The plant is located at Elginfield in lot 17, concession XVI, London township, Middlesex county. An early description is given by Montgomery (1930, pp. 137–138).

Plant

Two to three million buff-coloured drain tile are produced during the 9–10 month working season. Sixteen men are employed.

Clay is removed by an 8-yard Hancock scraper


UNIT
SAMPLE
HT.
SECTION
Scale 1 inch to 5 feet
10.0'
7.5'
4.0'
0.0'
-30.0'
RB 3
RB 2
RB 1
3
2
1
Black loamy topsoil
Rare pebbles
Rusty root channels and silty layers
Some rusting of silty layers
Pit floor
Well records show clay to extend 30 feet below the pit floor.
SURFACE CLAY
BROWN CLAY
GREY CLAY
O.D.M. 3298

Unit		Thickness (*feet*)
RB 3	CLAY: Olive-grey, drying buff; silty massive; rare limestone pebbles; black loamy topsoil.	2.5
RB 2	CLAY: Olive-grey clay and fine yellow sand; finely laminated in layers 1/16–1/8 inches thick; rusty staining of silt-sand layers and root channels common; stoneless.	3.5
RB 1	CLAY: Medium-grey, drying light-grey; silty, stoneless; finely laminated as above; rusty staining of silt layers common.	4.0

Figure 47–Rydall Brick and Tile Limited, pit section.

TABLE 192 Chemical Analyses: Rydall Brick and Tile Limited

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–4.0	4.0–7.0	7.5–10.0	0.0–10.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2				48.25
Al_2O_3				9.69
Fe_2O_3	3.47	3.53	3.88	3.37
CaO	16.4	15.2	6.43	14.3
MgO				4.35
Na_2O				1.10
K_2O				2.62
TiO_2				0.56
CO_2				13.06
H_2O+				1.92
H_2O-				1.27
SO_3				0.45
TOTAL				100.9
Loss on ignition	17.95	17.84	9.94	16.38
Soluble salts	0.80	0.76	0.75	

TABLE 193 Mineral Analyses: Rydall Brick and Tile Limited (A = abundant; B = moderate; C = minor)

Sample	1	2	3	Composite
Height above floor (*feet*)	0.0–4.0	4.0–7.5	7.5–10.0	0.0–10.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals				
Quartz	19	21	28	20
Calcite	21	15	3	14
Dolomite	18	13	3	12
Soda-lime feldspar	5	3	3	4
Potash feldspar	<0.5	<0.5	1	1
Amphibole	<1	<1	<1	<1
Clay minerals				
Illite	B	B	A	B
Chlorite	C	B	C	B
Expanding minerals	C	C	B	B*

*Montmorillonite.

TABLE 194 Ceramic Tests: Rydall Brick & Tile Ltd.

SAMPLE 1: 0.0′–4.0′

Water of plasticity (*percent*)	22
Lineal drying shrinkage (*percent*)	5.4
Pyrometric cone equivalent	4–5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4	0.4 expansion	0.4
Colour	pale salmon	cream	cream-buff
Hardness	moderately soft	moderately hard	hard
24-hour absorption (%)	20.2	18.4	17.2
5-hour boil absorption (%)	21.3	21.2	23.0
Specific gravity	1.66	1.62	1.67

SAMPLE 2: 4.0′–7.5′

Water of plasticity (*percent*)	23
Lineal drying shrinkage (*percent*)	5.6
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4	0	0.7
Colour	pale salmon	cream	buff-white
Hardness	moderately soft	moderately hard	hard
24-hour absorption (%)	20.2	18.7	16.6
5-hour boil absorption (%)	21.0	21.0	22.3
Specific gravity	1.66	1.63	1.67

SAMPLE 3: 7.5′–10.0′

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	6.1
Pyrometric cone equivalent	3–4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.4 expansion	0.7
Colour	salmon	salmon	salmon-brown
Hardness	soft	moderately hard	hard
24-hour absorption (%)	16.1	16.0	12.6
5-hour boil absorption (%)	17.7	19.0	17.0
Specific gravity	1.77	1.74	1.98

REMARKS: Briquettes are slightly overfired at cone 03, and are marked by a slight yellow scum.

drawn by a John Deere No. 820 tractor. It is discharged into an open-air stockpile at the plant, some 300 feet distant from the pit. A John Deere No. 1010 diesel front-end loader reclaims the clay from the yard and dumps it into a sub-floor pug feeder. A small covered stockpile is maintained in this area for use during periods of wet weather. The feeder is Mr. Rydall's own design and features three shafts, each with an independent clutch for simultaneous or solo operation. A 32-inch pair of Brewer smooth conical rolls, travelling at different speeds, is effective in removing hard lumps and minor stones. Extrusion is by an F-R-H Plymouth Special, operated in a single stream at the rate of 2,000 tile per hour under a vacuum of 13 to 19 inches. Tile are cut by an F-R-H cutter and are hacked in three tiers, 180 tile per car.

A 12-track tunnel dryer 105 feet long holds 20 cars per track for a total of 43,000 tile. An 8-track periodic room dryer of the same length is used for additional drying capacity over the week-ends. Its capacity is 29,000 tile and drying time is 48 hours. Drying is accomplished by the use of waste heat with an auxiliary booster. There are three beehive kilns with capacities of about 30,000 tile each. Tile are set 13 or 14 high in the kiln and are fired with natural gas. Peak temperatures are 1900°F at the top, 1700°F at floor level. Kilns are turned over on an 8-day cycle.

GEOLOGY

Patches of stratified stoneless clay are found in depressions in till plains and moraines in the central highland region of western Ontario. The region was largely free of ice during the latter part of the Wisconsinan stage, but was transgressed by meltwater streams that originated in the glaciers that surrounded it. The streams cut through brown calcareous silty till, that had been deposited by an earlier ice-sheet, and formed spillway deposits of sand and gravel in the ancient river beds, and stratified deposits of clay and silt in areas of quiet water.

At Elginfield, 40 feet of silty calcareous clay are indicated by well records. The clay was probably deposited in an early glacial lake prior to Lake Whittlesey. About 10 feet of this clay is exposed in the pit of Rydall Brick and Tile Limited. The pit is oval-shaped, 200 by 300 feet, with gently sloping faces resulting from the scraper method of excavation. A typical section is illustrated in figure 47 and described in the following notes. The results of chemical, mineralogical, and ceramic testing of three channel samples are given in tables 192, 193, 194.

Table 195 Chemical Analysis: St. Clements Tile Yard

Sample	1
Height above floor (*feet*)	0.0–4.0
	(*percent*)
SiO_2	57.46
Al_2O_3	11.6
Fe_2O_3	4.02
CaO	7.55
MgO	3.55
Na_2O	1.54
K_2O	3.06
TiO_2	0.62
CO_2	6.60
H_2O+	2.28
H_2O-	1.38
SO_3	0.54
Total	100.3
Loss on ignition	9.83
Soluble salts	0.89

Table 196 Mineral Analysis: St. Clements Tile Yard (B = moderate)

Sample	1
Height above floor (*feet*)	0.0–4.0
	(*percent*)
Non-clay minerals	
Quartz	33
Calcite	6
Dolomite	8
Soda-lime feldspar	6
Potash feldspar	1
Amphibole	0.5–5
Clay minerals	
Illite	B
Chlorite	B
Expanding minerals	B*

*Vermiculite.

Table 197 Ceramic Tests: St. Clements Tile Yard

sample 1: 0.0′–4.0′

Water of plasticity (*percent*)	23
Lineal drying shrinkage (*percent*)	4.0
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4 expansion	0.5 expansion	0.4
Colour	salmon	pale salmon	pink
Hardness	soft	soft	almost hard
24-hour absorption (%)	16.8	16.6	13.3
5-hour boil absorption (%)	18.5	18.8	17.3
Specific gravity	1.77	1.75	1.80

ST. CLEMENTS TILE YARD

A small plant on the south side of St. Clements ten miles northwest of Kitchener was managed by the late Mr. R. Kieswetter. The plant is just over 100 years old. It is located in lot 2, concession VIII, Wellesley township, Waterloo county. An early description is given by Montgomery (1930, pp. 156–157). The plant was closed after Mr. Kieswetter's death in 1962.

Plant

From 300,000 to 500,000 tile were produced during the 7-month working season. It was largely a family enterprise and few outside employees were hired. Tile were made in 4-, 5-, and 6-inch sizes, and a few large diameter pipe were made from concrete.

Clay was removed from the pit by means of a Massey Harris farm tractor with rear scraper. A small open-air stockpile was maintained at the plant, several hundred feet from the pit. The tractor and scraper loaded clay into a single-shaft pug feeder recessed into a wooden ramp. Clay was carried by a short belt to the Baird combined smooth rolls and extruder. Tile were cut by an automatic cutter and were carried to the drying racks by wheelbarrow.

Natural drying was accomplished in shed-covered racks four tiers high. Drying time was as short as three days in good weather. Two beehive kilns, having capacities of 20,000 and 22,000 tile, are enclosed in a corrugated steel quonset-type building. Firing was started with wood and finished with coal, and the kilns were on-fire for about 60 hours. The fired tile were a cream-yellow colour streaked with pink.

GEOLOGY

During the retreat of the last ice-sheet a number of shallow lakes or ponds were formed in depressions on the land surface. Such pondings were short-lived, the retreating ice-front often forming a part of the shoreline. In some cases thin deposits of stratified or varved clay were formed, but in others there was only a minor re-sorting of the top few feet of an earlier till.

At St. Clements, eight miles northwest of Kitchener, a shallow deposit of an almost stonefree massive clay was used for tile. The clay is medium-grey to brown-grey, and dries to a cream or buff colour. It is silty, limy, and moderately plastic. Blotchy iron stains, a few roots, and occasional limestone pebbles are present. The pit is 300 by 75 feet, with a face 4–6 feet deep, but older more extensive workings are still visible. A few inches of sod and topsoil were removed by stripping.

The results of chemical, mineralogical, and ceramic testing of a four-foot vertical channel sample are given in tables 195, 196, 197.

SUPERIOR BRICK AND TILE COMPANY LIMITED

The plant of Superior Brick and Tile Company Limited is located at Rosslyn, seven miles west of Fort William, on the north bank of the Kaministikwia River. The plant and clay pit are in lots 11 and 12, concession I, N.R., Paipoonge township, Thunder Bay district. A buff-burning clay is obtained at Dorion some 50 miles east of Fort William.

Plant

The plant employs 46 men during its four-month working season. Annual production runs to 2½ million brick of which 25 to 30 percent are Norman. Red, buff, and flashed colours are produced in a wide range of textures. Minor quantities of structural and drain tile are also made.

Clay is taken from the Rosslyn pit by two Land-leveler scrapers drawn by an International No. 340 Industrial tractor, or one of two Ford tractors, all rubber mounted. The ¾-yard bottom-discharge scrapers load a two-yard side-dump car from a raised ramp over a rail tramway. The car is winched up a wooden trestle and under the roof of a large covered storage area. The load can be discharged at any point to accomplish blending, or to maintain separate storage for various clays as the case may be. Haulage distance from the pit is about 750 feet. The storage building is of wood construction and is wedge-shaped with a base measuring about 100 by 75 feet. Clay is piled to a depth of about 20 feet.

The clay is reclaimed by scraping it into feed points in the floor of the storage building and transporting it by subfloor conveyor to a transfer point at one end of the building. It is elevated and conveyed to a 12-foot granulator feeder. Tempering water or dry grog can be added here or at the extruder as required. The grog is waste brick ground to minus eight mesh. It is stored in a plywood bin of about ten-cubic yard capacity and is added to the clay by a Meco disc feeder. Discharge from the granulator feeder passes through a set of 14-inch Raymond smooth rolls travelling at different speeds. A Steele No. 30E de-airing extruder is operated at 5,000 brick per hour. The die is lubricated by mineral oil under a pressure of 500 pounds per square inch. Brick are extruded under a vacuum of 22 to 27 inches and are cut by a Steele No. 18 cutter. A fairly wide range of texturing is available. Standard brick are hacked 500 to the car; Norman brick 380.

There are eight waste-heat tunnel dryers, each with two tracks, with a capacity of sixteen cars per track. Drying takes three days at 90° to 120°F. Six rectangular downdraft kilns, each 100 by 20 feet inside, have 28 fireboxes and two chimneys each. The individual kilns have a capacity of 175,000 to 200,000 Standard (eight-inch) brick. They are coal-fired to peak temperatures between 2000° and 2100°F and are operated on a 28-day cycle.

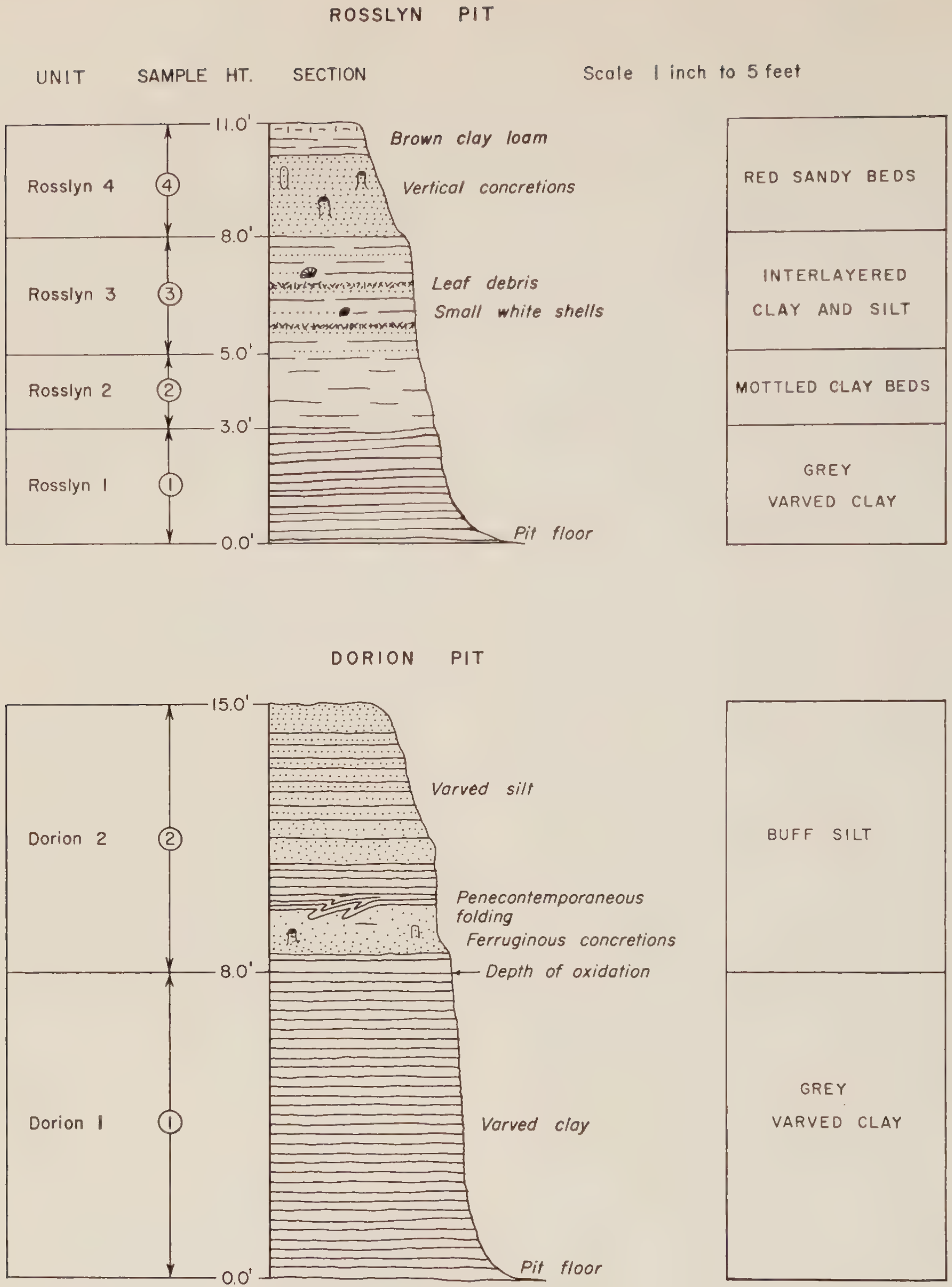
The large kiln capacity provides considerable storage, and brick are often left in the kiln until shipment. They are cubed on wooden pallets as removed from the kiln and are transported by fork-lift. Shipments are made by truck.

GEOLOGY

Great thicknesses of varved clay were reported by Keele (1924, pp. 127–128) in pits worked by former brick plants near the mouth of the Kaministikwia River at Fort William. The clay was deposited in glacial Lake Algonquin. As exposed in the river banks, the clay rests on gravel that may indicate that the Kaministikwia River was also a pre-Algonquin spillway. As Lake Algonquin receded, thin deltaic deposits of stratified sand and silt were spread over the varved clays (Zoltai 1963, p. 108).

At Rosslyn, six miles north of Fort William, the varved clay section is thin, and feed for the brick plant is largely stratified silt, sand, and clay deposited on the flood plain of the Kaministikwia River. Black leaf and pine needle debris, and scattered small white pelecypod shells, interlayered with the flood plain deposits, indicate a warmer climate than that which prevailed during deposition of the varved clays.

The clay pit of Superior Brick and Tile Company Limited is located on the east bank, fifty feet above the river. The pit is semicircular, 700 by 400 feet, with gently sloping faces to a maximum depth of eleven feet. A typical section is illustrated in figure 48 and described in the accompanying notes. The results of chemical, mineralogical and ceramic testing of four channel samples are given in tables 198, 199, 200.


ROSSLYN PIT
UNIT
SAMPLE HT.
SECTION
Scale 1 inch to 5 feet
Rosslyn 4
Rosslyn 3
Rosslyn 2
Rosslyn 1
④
③
②
①
11.0'
8.0'
5.0'
3.0'
0.0'
Brown clay loam
Vertical concretions
Leaf debris
Small white shells
Pit floor
RED SANDY BEDS
INTERLAYERED CLAY AND SILT
MOTTLED CLAY BEDS
GREY VARVED CLAY
DORION PIT
Dorion 2
Dorion 1
②
①
15.0'
8.0'
0.0'
Varved silt
Penecontemporaneous folding
Ferruginous concretions
Depth of oxidation
Varved clay
Pit floor
BUFF SILT
GREY VARVED CLAY

O. D. M. 3299

Unit		Thickness (*feet*)
ROSSLYN PIT		
ROSSLYN 4	SAND: Red-brown with numerous dark grains; fine-medium grained; thinly stratified; numerous cylindrical ferruginous concretions; a few fine roots; brown clay and loam at top.	3.0
ROSSLYN 3	CLAY AND SILT: Mauve-pink clay and blue-grey silt in equal portions; stoneless; stratified in layers up to ¾-inch thick, averaging ⅛-inch; occasional ⅜-inch white pelecypod shells; several thin brown-black seams of leaf and pine needle fragments; rare thin lenses of fine yellow sand.	3.0
ROSSLYN 2	CLAY: Mottled grey-brown-pink, drying pale red-brown; porous, loamy, stoneless; occasional root channels.	2.0
ROSSLYN 1	CLAY: Medium grey clay and mauve-brown silt; varved in layers up to 1 inch thick, averaging ⅛-inch; occasional fine black roots.	3.0
DORION PIT		
DORION 2	SILT: Olive-grey, drying pale buff; stoneless; irregularly varved silt, fine sand, and minor grey clay; occasional large ferruginous cylindrical concretions and oxidized root channels.	7.0
DORION 1	CLAY: Green-grey clay and pale grey silt; stoneless; uniformly varved in layers ¼–½-inch thick.	8.0

Figure 48—Superior Brick and Tile Co. Ltd., pit section.

TABLE 198 Chemical Analyses: Superior Brick and Tile Co. Ltd.; Rosslyn Pit

Sample	1	2	3	4	Composite
Height above floor (*feet*)	0.0–3.0	3.0–5.0	5.0–8.0	8.0–11.0	0.0–11.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
SiO_2					56.28
Al_2O_3					12.1
Fe_2O_3	8.02	7.94	8.00	10.6	8.60
CaO	7.47	8.58	7.80	4.33	7.08
MgO					4.58
Na_2O					1.87
K_2O					2.14
TiO_2					0.76
CO_2					3.32
H_3O+					2.07
H_2O-					1.26
SO_3					0.61
TOTAL					100.7
Loss on ignition	5.84	8.54	7.77	4.68	7.19
Soluble salts	0.80	1.04	0.42	0.35	

TABLE 199 Mineral Analyses: Superior Brick and Tile Co. Ltd.; Rosslyn Pit
(A = abundant; B = moderate; C = minor; ND = not detected)

Sample	1	2	3	4	Composite
Height above floor (*feet*)	0.0–3.0	3.0–5.0	5.0–8.0	8.0–11.0	0.0–11.0
	(*percent*)	(*percent*)	(*percent*)	(*percent*)	(*percent*)
Non-clay minerals					
Quartz	32	18	25	33	28
Calcite	4	6	5	ND	3
Dolomite	3	4	3	ND	4
Soda-lime feldspar	12	11	9	8	11
Potash feldspar	<0.5	<0.5	<0.5	4	3
Amphibole	0.5–5	<1	ND	<1	0.5–5
Clay minerals					
Illite	B	B	B	B	B
Chlorite	B	B	B	C	B
Expanding minerals	C	B	B	A	B*

*Montmorillonite.

Table 200 Ceramic Tests: Superior Brick & Tile Co. Ltd.; Rosslyn Pit

SAMPLE 1: 0.0′–3.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.7
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3 expansion	0.4	3.0
Colour	dark tan	dusky pink	dusky red
Hardness	moderately soft	almost hard	hard
24-hour absorption (%)	16.1	16.2	9.2
5-hour boil absorption (%)	18.2	18.3	12.6
Specific gravity	1.82	1.82	2.03

REMARKS: Briquettes are well-fired at cone 03 but are marked by heavy yellow scum.

SAMPLE 2: 3.0′–5.0′

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	4.9
Pyrometric cone equivalent	25

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.7	0.7	8.6
Colour	dark tan	salmon-pink	red-brown
Hardness	almost hard	almost hard	very hard
24-hour absorption (%)	17.6	14.6	2.2
5-hour boil absorption (%)	18.4	18.2	2.8
Specific gravity	1.80	1.80	2.40

REMARKS: Briquettes are overfired at cone 03. Yellow scum is common on briquettes fired to cones 06 and 03.

SAMPLE 3: 5.0′–8.0′

Water of plasticity (*percent*)	25
Lineal drying shrinkage (*percent*)	5.2
Pyrometric cone equivalent	3

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.4	1.1	9.9
Colour	dark tan	salmon-pink	red-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	16.5	14.3	0.14
5-hour boil absorption (%)	17.1	15.6	0.23
Specific gravity	1.83	1.88	2.52

REMARKS: Yellow scum is common on all fired briquettes. Briquettes are overfired at cone 03.

SAMPLE 4: 8.0′–11.0′

Water of plasticity (*percent*)	22
Lineal drying shrinkage (*percent*)	3.5
Pyrometric cone equivalent	7

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	3.6
Colour	dark salmon	salmon-red	red-brown
Hardness	almost hard	hard	very hard
24-hour absorption (%)	15.9	14.6	9.7
5-hour boil absorption (%)	21.2	20.3	15.4
Specific gravity	1.76	1.78	1.93

REMARKS: Briquettes are slightly overfired but undeformed at cone 03. No scum.

Table 201 Partial Chemical Analyses: Superior Brick & Tile Co. Ltd.; Dorion Pit

Sample	1	2
Height above floor (*feet*)	0.0–8.0	8.0–15.0
	(*percent*)	(*percent*)
Fe_2O_3	5.55	4.76
CaO	15.7	14.2
Loss on ignition	15.14	11.2
Soluble salts	0.36	0.42

Table 202 Mineral Analyses: Superior Brick & Tile Co. Ltd.; Dorion Pit

B = moderate; C = minor; ND = not detected)

Sample	1	2
Height above floor (*feet*)	0.0–8.0	8.0–15.0
	(*percent*)	(*percent*)
Non-clay minerals		
Quartz	15	22
Calcite	12	10
Dolomite	7	8
Soda-lime feldspar	4	15
Potash feldspar	ND	1
Amphibole	<1	<1
Clay minerals		
Illite	B	B
Chlorite	B	B
Expanding minerals	C	C

TABLE 203 Ceramic Tests:
Superior Brick and Tile Co. Ltd.; Dorion Pit

SAMPLE 1: 0.0′–8.0′

Water of plasticity (*percent*)	27
Lineal drying shrinkage (*percent*)	6.2
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	1.2	3.2	6.4
Colour	tan	buff	yellow
Hardness	hard	very hard	very hard
24-hour absorption (%)	18.7	14.1	7.7
5-hour boil absorption (%)	19.5	15.9	9.6
Specific gravity	1.76	1.87	2.04

REMARKS: Briquettes are well-fired and attractive at cone 06, but overfired at cone 03.

SAMPLE 2: 8.0′–15.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	3.4
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.3 expansion	0	0.9
Colour	tan	cream-grey	grey-buff
Hardness	almost hard	almost hard	hard
24-hour absorption (%)	20.4	19.6	16.2
5-hour boil absorption (%)	22.4	23.0	21.6
Specific gravity	1.69	1.70	1.76

The company also obtains clay from Dorion, fifty miles east of Fort William. The pit is located at roadside, on the south bank of the Fish Hatchery creek, one mile west of the Dorion intersection on highway no. 17. The 15-foot section of varved Algonquin clay and silt is also illustrated and described in figure 48. The results of chemical, mineralogical, and ceramic testing of two vertical channel samples are given in tables 201, 202, 203.

TORONTO BRICK COMPANY, LIMITED

This company's Greenwood Avenue plant in east Toronto was one of the few remaining soft-mud plants in the province. Built in 1912 by John Price the plant was taken over by the Toronto Brick Company in 1924. It was closed in 1962, but a similar brick is now made at the Don Valley plant using Dundas shale in soft-mud machines. An early description of the plant is given by Montgomery (1930, pp. 162–163).

Plant

Production in recent years had fluctuated between three and five million brick annually—about one-third of the volume of 35 years ago. The company wisely retained the original brick moulds bearing the "J. Price" stamp. These brick established an early reputation for durability and attractive dark-red colour, and production had only fallen off as a result of higher operating costs and increased competition from stiff-mud brick. Brick made entirely from clay were marketed in three categories depending on the intensity of the red colour—"Dark flash," "Medium range," and "Medium flash." A somewhat harder brick with a lower firing temperature was made with the addition of 30 percent Dundas shale. About thirty men were employed intermittently for an average of six to eight months per year.

Clay was taken from the bank by light blasting of small sections at a time. Between six and ten horizontal holes were drilled by two-inch hand-auger to depths of thirty inches at closely spaced intervals. They were lightly loaded with eight-inch sticks of dynamite and were either detonated electrically or by fuse. A one-yard Caterpillar D4 Traxcavator loaded one of two 1¼-yard side-dump cars on rail. It was hauled by a one-cylinder converted Falcon farm tractor a few hundred feet to the base of the west pit wall. A 25 h.p. cable-hoist winched it up the steep incline to the plant, while the Falcon returned to the face with the empty car. There was no stockpile at the plant as the best colour was produced by freshly-blasted clay. The car dumped directly into a thirteen-foot Parkhill single-shaft pug feeder where tempering water was added as required. A 36-inch diameter, 24-inch, double smooth roll crusher was set for ⅛-inch opening. It was followed by further mixing in a second Parkhill single-shaft pug mill. Two Parkhill Martin-A-Brick machines were capable of producing 32,000 brick per day. Unless the demand warranted both, it was normal to operate only one machine at a time, making 2,400 brick per hour. The wood moulds were washed after each use, and dusted with a fine screened sand obtained from a pit near Claremont. Minor amounts of borax, ferro-red, and manganese-dioxide were added to the sand for colour

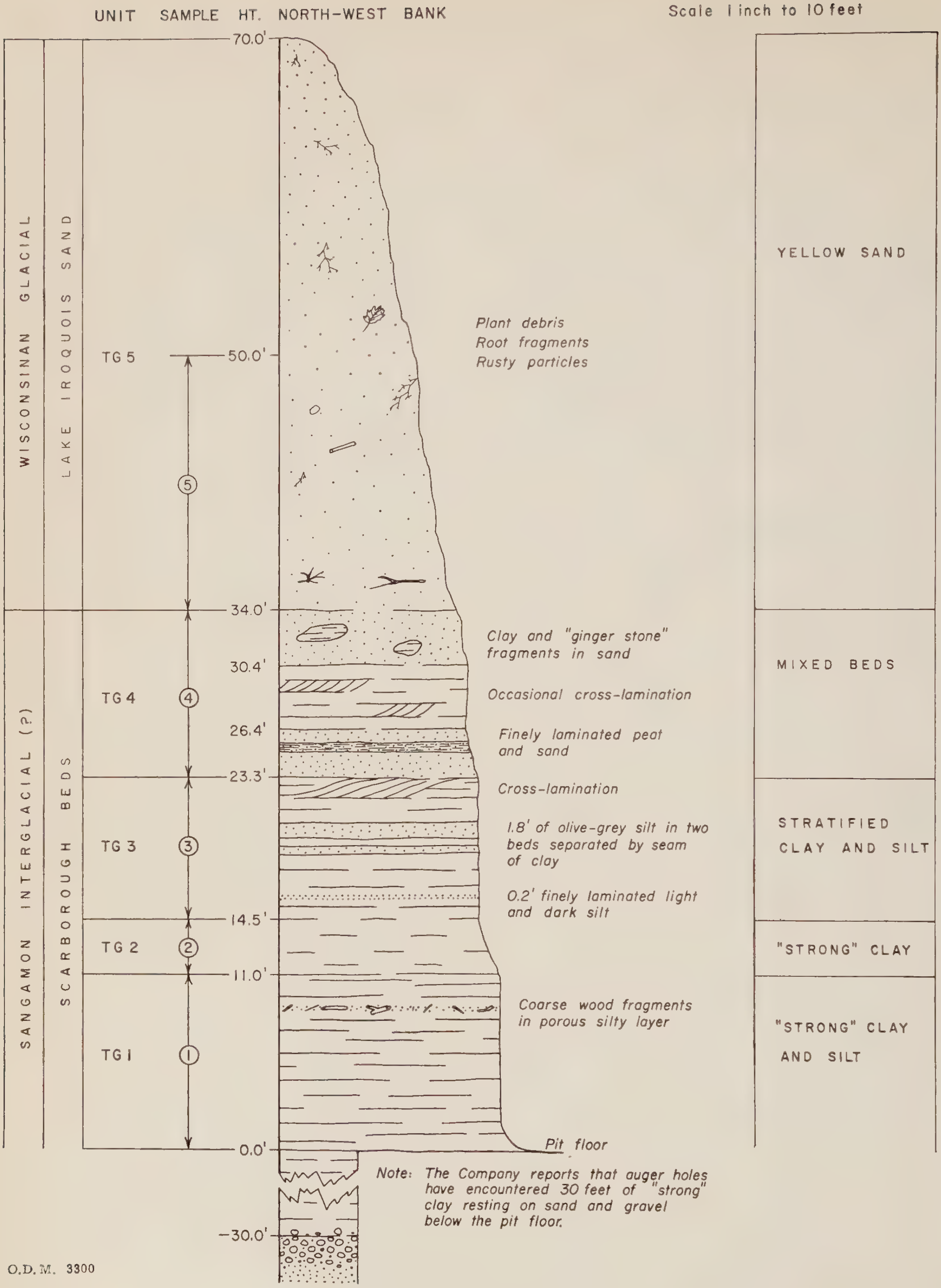

UNIT
SAMPLE
HT.
NORTH-WEST BANK
Scale 1 inch to 10 feet
WISCONSINAN GLACIAL
LAKE IROQUOIS SAND
SANGAMON INTERGLACIAL (?)
SCARBOROUGH BEDS
TG 5
TG 4
TG 3
TG 2
TG 1
⑤
④
③
②
①
70.0'
50.0'
34.0'
30.4'
26.4'
23.3'
14.5'
11.0'
0.0'
-30.0'
Plant debris
Root fragments
Rusty particles
Clay and "ginger stone" fragments in sand
Occasional cross-lamination
Finely laminated peat and sand
Cross-lamination
1.8' of olive-grey silt in two beds separated by seam of clay
0.2' finely laminated light and dark silt
Coarse wood fragments in porous silty layer
Pit floor
Note: The Company reports that auger holes have encountered 30 feet of "strong" clay resting on sand and gravel below the pit floor.
YELLOW SAND
MIXED BEDS
STRATIFIED CLAY AND SILT
"STRONG" CLAY
"STRONG" CLAY AND SILT
O.D.M. 3300

Figure 49—Toronto Brick Co. Ltd., Greenwood Avenue pit section.

TABLE 204 Chemical Analyses: Toronto Brick Company Limited; Greenwood Avenue Plant

Sample	1	2	3	4	Composite	5
Height above floor *(feet)*	0.0–11.0	11.0–14.5	14.5–23.3	23.3–34.0	0.0–34.0	34.0–50.0
	(percent)	*(percent)*	*(percent)*	*(percent)*	*(percent)*	*(percent)*
SiO_2					60.35	
Al_2O_3					12.4	
Fe_2O_3	4.48	4.19	4.63	4.35	4.31	3.78
CaO	5.77	5.70	6.30	5.70	6.20	3.30
MgO					2.31	
Na_2O					2.00	
K_2O					2.62	
TiO_2					0.60	
CO_2					4.26	
H_2O+					1.88	
H_2O-					1.27	
SO_3					0.56	
TOTAL					98.8	
Loss on ignition	7.05	6.41	7.92	5.88	7.85	2.55
Soluble salts	1.20	1.06	1.16	1.02	0.79	

TABLE 205 Mineral Analyses: Toronto Brick Company Limited; Greenwood Avenue Plant
(A = abundant; B = moderate; C = minor; ND = not detected)

Sample	1	2	3	4	Composite	5
Height above floor *(feet)*	0.0–11.0	11.0–14.5	14.5–23.3	23.3–34.0	0.0–34.0	34.0–50.0
	(percent)	*(percent)*	*(percent)*	*(percent)*	*(percent)*	*(percent)*
Non-clay minerals						
Quartz	34	24	37	33	30	41
Calcite	4	4	3	4	4	2
Dolomite	2	6	2	3	4	<0.5
Soda-lime feldspar	8	6	6	9	9	9
Potash feldspar	1	2	1	2	4	1
Amphibole	0.5–5	0.5–5	0.5–5	0.5–5	0.5–5	0.5–5
Gypsum						trace
Clay minerals						
Illite	A	B	A	B	B	A
Chlorite	A	A	A	A	B	B
Expanding minerals	ND	C	ND	C	B*	ND

*Montmorillonite.

Description of Greenwood Avenue pit, Toronto Brick Co. Ltd., figure 49.

Unit		Thickness *(feet)*
TG 5	SAND: Brown, drying yellow; medium-grained; uniform, stoneless, massive; rarely stratified; inclusions of rusty sulphides, roots, and plant fragments are rather common.	36
TG 4	SILT AND CLAY: Olive-grey, drying grey-buff; medium-bedded silt layers, and very finely laminated clay, sand, and peat layers; lenses of yellow "ginger stone" and disoriented clay fragments are rather common in the silt beds; minor cross-bedding.	10.7
TG 3	CLAY AND SILT: Olive-grey, drying grey-buff; irregularly stratified from extremely fine to about 1-inch, averaging ½-inch; hard, brittle, yellow weathering, pale grey "ginger stone" layers, ⅜ inch thick, occur at about 1-foot intervals; minor cross-bedding.	8.8
TG 2	CLAY: Pale olive-grey, drying cream-buff; silty, stoneless; indistinctly bedded at 2–4 inches; bedding planes marked by veneers of fine micaceous sand.	3.5
TG 1	CLAY: Olive-grey, drying pale grey-buff; smooth to slightly silty; stoneless, plastic; stratified in layers ¼–3 inches thick, averaging ¾-inch; bedding planes marked by very thin (less than ¼ inch) seams of dark brown to black plant debris, fine silver-white mica flakes, or yellow silt; a few coarse wood fragments in silty layers.	11.0

TABLE 206 Ceramic Tests: Toronto Brick Co. Ltd.; Greenwood Avenue Plant

SAMPLE 1: 0.0′–11.0′

Water of plasticity (*percent*)	23
Lineal drying shrinkage (*percent*)	5.3
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0	3.2
Colour	salmon	pale salmon	red-brown
Hardness	soft	hard	very hard
24-hour absorption (%)	15.7	15.6	5.9
5-hour boil absorption (%)	18.2	18.6	8.9
Specific gravity	1.75	1.75	2.03

REMARKS: Briquettes are slightly overfired and marked by a moderate amount of yellow scum at cone 03.

SAMPLE 2: 11.0′–14.5′

Water of plasticity (*percent*)	20
Lineal drying shrinkage (*percent*)	3.9
Pyrometric cone equivalent	5

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.3 expansion	2.3
Colour	pale salmon	pale salmon	red-brown
Hardness	moderately hard	moderately hard	hard
24-hour absorption (%)	15.6	15.4	9.8
5-hour boil absorption (%)	18.6	19.6	15.2
Specific gravity	1.77	1.75	1.88

REMARKS: Briquettes are slightly overfired and marked by a moderate amount of yellow scum at cone 03.

SAMPLE 3: 14.5′–23.3′

Water of plasticity (*percent*)	22
Lineal drying shrinkage (*percent*)	4.7
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0	0.2 expansion	2.3
Colour	pale salmon	pale salmon	red-brown
Hardness	moderately hard	almost hard	hard
24-hour absorption (%)	16.3	16.2	10.3
5-hour boil absorption (%)	18.7	19.1	14.4
Specific gravity	1.73	1.74	1.88

REMARKS: Briquettes fired to cone 03 and are marked by a slight yellow scum.

SAMPLE 4: 23.3′–34.0′

Water of plasticity (*percent*)	21
Lineal drying shrinkage (*percent*)	4.7
Pyrometric cone equivalent	4

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.2 expansion	0.5 expansion	0.5
Colour	pale salmon	pale salmon	red-brown
Hardness	moderately hard	almost hard	hard
24-hour absorption (%)	15.6	15.8	12.4
5-hour boil absorption (%)	18.4	18.9	17.2
Specific gravity	1.77	1.76	1.83

REMARKS: Briquettes fired to cone 03 are marked by a moderate amount of yellow scum.

SAMPLE 5: 34.0′–50.0′

Water of plasticity (*percent*)	17
Lineal drying shrinkage (*percent*)	3.2
Pyrometric cone equivalent	8

	Cones		
	010 (1660°F)	06 (1840°F)	03 (1980°F)
Lineal firing shrinkage (%)	0.5 expansion	0.5 expansion	0.7
Colour	salmon	salmon	red-brown
Hardness	rather soft	rather soft	moderately hard
24-hour absorption (%)	13.0	13.3	11.5
5-hour boil absorption (%)	18.3	19.3	17.4
Specific gravity	1.78	1.77	1.82

REMARKS: All briquettes are marked by a moderate yellow scum.

improvement of the clay-shale brick. Brick were hacked 300 per car and moved to the dryer on rail.

A 23-track waste-heat tunnel dryer, 110 feet long, held sixteen cars on each track. Drying time was 72 hours, and temperature at the hot end was 135°F. Eight beehive kilns, with inside diameters of 30 feet, held 50,000 to 80,000 brick each. Slow firing for 36 hours with wood preceded 132 hours burning with soft coal. Dried brick were palletised and moved to the kilns by forklift trucks for manual setting. Brick composed of 30 percent shale were set in the lower third of the kiln and the clay brick were placed on top. Temperature gradient in the kiln during firing accounted for differences in the intensity of the red colour, permitting the marketing of the three types mentioned previously. The peak firing temperature was about 1950°F.

Brick were sorted in the yard for colour and culls. They were loaded manually onto trucks for shipment, and the layers were separated by straw to protect the finish.

GEOLOGY

Interglacial clay of the cool-climate Scarborough Beds was used exclusively by former brick plants located on either side of Greenwood Avenue, just north of the railway tracks between Danforth Avenue and Gerrard Street, in southeastern Toronto. The clay belongs to the Sangamon interglacial stage, and was deposited in a lake 200 feet deeper than Lake Ontario more than 100,000 years ago, prior to the latest (Wisconsinan) glacial stage. The oxidized colour and low content of lime indicates that it was derived from a deeply-weathered land surface. The clay has been described in reports by Baker (1906, pp. 109–110), Keele (1924, pp. 106–107), Coleman (1933, pp. 19–23), and Terasmae (1960).

In 1961, clay was being taken from the northwest corner of the pit. Here 34 feet of stratified clay, silt, and sand of the Scarborough Beds are overlain by an equal depth of medium-grained yellow deltaic sand deposited at the time of Lake Iroquois. Elsewhere in the pit, the sand cover was reported to have been much thinner (Coleman 1933, p. 21) and the clay section, in some cases, thicker (Keele 1924, p. 106). The results of auger drilling by Toronto Brick Company Limited in 1959 indicate that Scarborough Bed clay continues for 30 feet below the pit floor. Peaty layers and wood fragments interlayered with the Scarborough clay confirm the non-glacial environment during deposition. Clay fragments and whorls in a massive silt bed at the top of the clay section are thought by Coleman (1933, p. 21) to represent crumpling and distortion by the over-riding Wisconsinan ice-sheet. Thin hard "ginger stone" lenses occasionally found in the section are formed by the cementing of certain silty layers by iron-bearing solutions arising from the peaty accumulations.

The section is illustrated in figure 49 and described in the accompanying notes. The results of chemical, mineralogical, and ceramic testing of vertical channel samples are given in tables 204, 205, 206.

SELECTED REFERENCES

Alexander, L. E. and Klug, H. P.

1948 : Basic aspects of X-ray absorption in quantitative diffraction analysis of powder mixtures; Analytical Chem., Vol. 20, pp. 886–889.

Antevs, E.

1925 : Retreat of the last ice-sheet in eastern Canada; Geol. Surv. Canada, Mem. 146.

ASTM Specifications

1962 : Various specifications for structural clay masonry units; American Society for Testing and Materials, book 5, Philadelphia, Pennsylvania.

Baker, M. B.

1906 : Clay and the clay industry of Ontario; Ontario Bur. Mines, Vol. XV, pt. 2.

Bell, K. E.

1962 : Some aspects of the plastic and related properties of Queenston shales; Jour. Canadian Ceramic Soc., Vol. 31, pp. 106–119.

1965 : The influence of lime on the thermal expansion of clay; Canada Dept. Mines and Tech. Surveys, Mines Branch, Report MPI–65–10.

Brady, J. G.

1957 : Physical properties and differential thermal analysis of some Canadian clays and shales; Jour. Canadian Ceramic Society, Vol. 26, pp. 71–89.

Brady, J. G., Bell, K. E., and Zemgals, L. K.

1965 : Some methods of investigating firing problems; Jour. Canadian Ceramic Soc., Vol. 34, pp. 9–20.

Brady, J. G. and Dean, R. S.

1965 : The composition and properties of ceramic clays and shales of Ontario; Canada Dept. Mines and Tech. Surveys, Mines Branch, Report MPI-65-8.

Caley, J. F.

1940 : Palaeozoic geology of the Toronto-Hamilton area, Ontario; Geol. Surv. Canada, Mem. 224.

1943 : Palaeozoic geology of the London area, Ontario; Geol. Surv. Canada, Mem. 237.

Chapman, L. J. and Putnam, D. F.

1951 : The physiography of southern Ontario; University of Toronto Press.

Coleman, A. P.

1909 : Lake Ojibway; last of the great glacial lakes; Ontario Bur. Mines, Vol. XVIII, 1909, pt. 1, pp. 284–293.

1933 : The Pleistocene of the Toronto region; Ontario Dept. Mines, Vol. XLI, 1932, pt. 7.

1937 : Lake Iroquois; Ontario Dept. Mines, Vol. XLV, 1936, pt. 7, pp. 1–36.

Collins, G. A. and Swan, A. G.

1954 : Differential thermal analysis; Canadian Mining and Met. Bull., August, 1954, pp. 533–538.

Corbett, P. M. and Runnalls, O. J. C.

1949 : Experiments to improve the working properties of local shales; Jour. Canadian Ceramic Soc., Vol. 18, pp. 45–56.

CSA Specifications

1958 : Structural clay masonry units; specifications of the Canadian Standards Assoc. reprinted by the Brick and Tile Institute of Ontario, Willowdale.

Dawson, A. S.

1952 : The use of ceramic tests in the correlation of strata; Canadian Mining and Met. Bull. August 1952, pp. 479–483.

Dreimanis, A.

1958 : Wisconsin stratigraphy at Port Talbot on the north shore of Lake Erie, Ontario; Ohio Journal of Science, Ohio State University, Columbus, Ohio, U.S.A., Vol. 58, No. 2, pp. 56–84.

1960 : Pre-classical Wisconsin in the eastern portion of the Great Lakes region, North America; Twenty-first International Geol. Congress, pt. 4, pp. 108–119.

1961 : Quantitative gasometric determination of calcite and dolomite by using Chittick apparatus; *unpublished manuscript.*

1964 : Pleistocene geology of the St. Thomas area (west half); Ontario Dept. Mines, Prelim. map No. 238.

Dyer, W. S.

1925 : The stratigraphy and paleontology of Toronto and vicinity; part B: Stratigraphy and correlation of the Credit River section; Ontario Dept. Mines, Vol. XXXII, 1923, pt. 7, pp. 117–134.

Elson, J. A.

1957 : Lake Agassiz and the Mankato-Valders problem; Science, Vol. 126, pp. 999-1002.

Flint, R. F.
1957 : Glacial and Pleistocene geology; John Wiley and Sons Inc., New York, U.S.A.

Fritz, M. A.
1926 : The stratigraphy and paleontology of the Workman's Creek section of the Cincinnatian series of Ontario; Royal Society Canada, Proceedings and Transactions, Series 3, Vol. 20, sec. IV, pp. 77–107.

Gadd, N. R.
1963 : Surficial geology of Ottawa map-area, Ontario and Quebec; Geol. Surv. Canada, Paper 62-16.

Geological Association of Canada
1958 : Glacial map of Canada.

Goldthwait, R. P.
1959 : Scenes in Ohio during the last ice age; Ohio Journal of Science, Ohio State University, Columbus, Ohio, U.S.A., Vol. 59, pt. 4, pp. 193–216.

Graham, W.
1954 : Efflorescence: some causes and prevention; Canadian Mining and Met. Bull., November, 1954, pp. 758–760.
1958 : Structural clay masonry units; 1954 Specifications of the Canadian Standards Association, A82.1, A82.2, A82.7; reprint by the Brick and Tile Institute of Ontario, Willowdale.

Grim, R. E.
1953 : Clay mineralogy; McGraw-Hill Book Co. Inc., New York.

Groskaufmanis, E.
1958 : Ceramic glazes on structural clay materials; Jour. Canadian Ceramic Soc., Vol. 27, pp. 108–111.

Guillet, G. R.
1964 : Clay and shale in Ontario, a review; Ontario Dept. Mines, P.R. 1964–2.

Harward, M. E. and Theisen, A. A.
1962 : Problems in clay mineral identification by X-ray diffraction; Soil Science Society of America, Proceedings, Vol. 26, No. 4, pp. 335–341.

Hewitt, D. F., and Karrow, P. F.
1963 : Sand and gravel in southern Ontario; Ontario Dept. Mines, Industrial Mineral Report No. 11.

Hoffman, D. W., Matthews, B. C., and Wicklund, R. E.
1964 : Soil associations of southern Ontario; Report *No. 30 of the* Ontario Soil Survey, Ontario Dept. Agriculture.

Hough, J. L.
1958 : Geology of the Great Lakes; University of Illinois Press, Urbana, Illinois, U.S.A.

Irwin, R. W.
1963 : Farm tile drainage assistance; Ontario Dept. Agriculture, publication No. 4.

Johnston, W. A.
1915 : Rainy River district, Ontario; Surficial geology and soils; Geol. Surv. Canada, Mem. 82.
1917 : Pleistocene and Recent deposits in the vicinity of Ottawa, with a description of the soils; Geol. Surv. Canada, Mem. 101.
1946 : Glacial Lake Agassiz, with a special reference to the mode of deformation of the beaches; Geol. Surv. Canada, Bull. 7.

Karrow, P. F.
1962 : Preliminary report on the Pleistocene geology of the Scarborough area; Ontario Dept. Mines, P.R. 1962-1.
1963 : Pleistocene geology of the Hamilton-Galt area; Ontario Dept. Mines, Geol. Report No. 16.

Karrow, P. F., Clark, J. R., and Terasmae, J.
1961 : The age of Lake Iroquois and Lake Ontario; Journal of Geology, Chicago University, Chicago, U.S.A., Vol. 69, No. 6, pp. 659–667.

Keele, J.
1924 : Preliminary report on the clay and shale deposits of Ontario; Geol. Surv. Canada, Mem. 142.

Klinefelter, T. A. and Hamlin, H. P.
1957 : Syllabus of clay testing; U.S. Bureau of Mines, Bull. 565.

Leroux, J., Lennox, D. H., and Kay, K.
1953 : Direct quantitative X-ray analysis by diffraction-absorption technique; Analytical Chem., Vol. 25, pp. 740–743.

Leverett, F. and Taylor, F. B.
1915 : The Pleistocene of Indiana and Michigan, and the history of the Great Lakes; United States Geol. Surv., Washington, D.C., U.S.A., Mono. 53.

Matthews, J. G.

1951 : Lightweight concrete aggregates from clays and shales; Canadian Mining and Met. Bull., July, 1951, pp. 489–492.

1952 : Preliminary report on coated lightweight concrete aggregate from Canadian clays and shales, part III, Ontario; Canada Dept. Mines and Tech. Surveys, Mines Branch, Memo. series No. 121.

Milligan, V., Soderman, L. G., and Rutka, A.

1962 : Experience with Canadian varved clays; Journal of the Soil Mechanics and Foundations Division, Proceedings of the American Society of Civil Engineers, Vol. 88, No. SM4, August, 1962.

Montgomery, R. J.

1930 : The ceramic industry of Ontario; Ontario Dept. Mines, Vol. XXXIX, 1930, pt. 4.

Naish, W. M.

1953 : Conditioning and extruding a low plastic shale; Jour. Canadian Ceramic Soc., Vol. 22, pp. 70–74.

Parks, W. A.

1925 : The stratigraphy and paleontology of Toronto and vicinity; part A: Stratigraphy and correlation of the Dundas formation; Ontario Dept. Mines, Vol. XXXII, 1923, pt. 7, pp. 89–116.

Phillips, J. G.

1955 : The sampling and examination of clay and shale deposits; Canada Dept. Mines and Technical Surveys, Mines Branch, Industrial Minerals Info. Circ. No. IM-2.

Prest, V. K.

1957 : Pleistocene geology and surficial deposits; *chapter VIII of* Geology and Economic Minerals of Canada; Geol. Surv. Canada, Econ. Geol. Series No. 1, 4th edition, pp. 443–495.

Sadler, A. G.

1962 : The mineral constitution of some Ordovician shales of eastern and southern Ontario; Canada Dept. Mines and Tech. Surveys, Mines Branch, Research Report 94.

Sanford, B. V.

1961 : Subsurface stratigraphy of Ordovician rocks in southwestern Ontario; Geol. Surv. Canada, Paper 60-26.

1964 : Catalogue of Ontario well samples at the Geological Survey of Canada, Ottawa; Geol. Surv. Canada, Paper 63–46.

Sanford, B. V. and Brady, W. B.

1955 : Palaeozoic geology of the Windsor-Sarnia area, Ontario; Geol. Surv. Canada, Mem. 278.

Satterly, J.

1943 : Mineral occurrences in Parry Sound district; Ontario Dept. Mines, Vol. LI, 1942, pt. 2.

Searle, A. B. and Grimshaw, R. W.

1959 : The chemistry and physics of clays and other ceramic materials; 3rd edit., Ernest Benn Ltd., London, England.

Stauffer, C. R.

1915 : The Devonian of southwestern Ontario; Geol. Surv. Canada, Mem. 34.

Terasmae, J.

1958 : Non-glacial deposits along Missinaibi River, Ontario; *part III of* Contributions to Canadian Palynology; Geol. Surv. Canada, Bull. 46.

1960 : A palynological study of Pleistocene glacial beds at Toronto; *part II of* Contributions to Canadian Palynology No. 2; Geol. Surv. Canada, Bull. 56.

Terasmae, J. and Hughes, O. L.

1960a: Glacial retreat in the North Bay area, Ontario; Science, Cambridge, Mass., U.S.A., Vol. 131, pp. 1444–1446.

1960b: A palynological and geological study of Pleistocene deposits in the James Bay lowlands, Ontario; Geo. Surv. Canada, Bull. 62.

Watt, A. K.

1954 : Correlation of the Pleistocene geology as seen in the subway with that of the Toronto region, Canada; Geol. Assoc. Canada, Vol. 6, pt. 2.

1957 : Pleistocene geology and ground-water resources of the township of North York, York county; Ontario Dept. Mines, Vol. LXIV, 1955, pt. 7.

Wilson, H. S.

1962 : Development of the Canadian lightweight aggregate industry; Canada Dept. Mines and Tech. Surveys, Mines Branch, Info. Circular 137.

1963 : Lightweight concrete aggregates from clays and shales in Ontario; Canada Dept. Mines and Tech. Surveys, Mines Branch, Tech. Bull. 51.

1965 : Aggregates, Lightweight; Preprint for the Canadian Minerals Yearbook 1964, Queen's Printer, Mineral Resources Division, Ottawa.

Winder, C. G.
1961 : Lexicon of Paleozoic names in southwestern Ontario; University of Toronto Press, Toronto.
Zoltai, S. C.
1961 : Glacial history of part of northwestern Ontario; Proceedings, Geol. Assoc. Canada, Vol. 13, pp. 61–83.
1963 : Glacial features of the Canadian Lakehead area; Ontario Dept. Lands and Forests, Research Branch, Contribution No. 63–64, Maple, Ontario.

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